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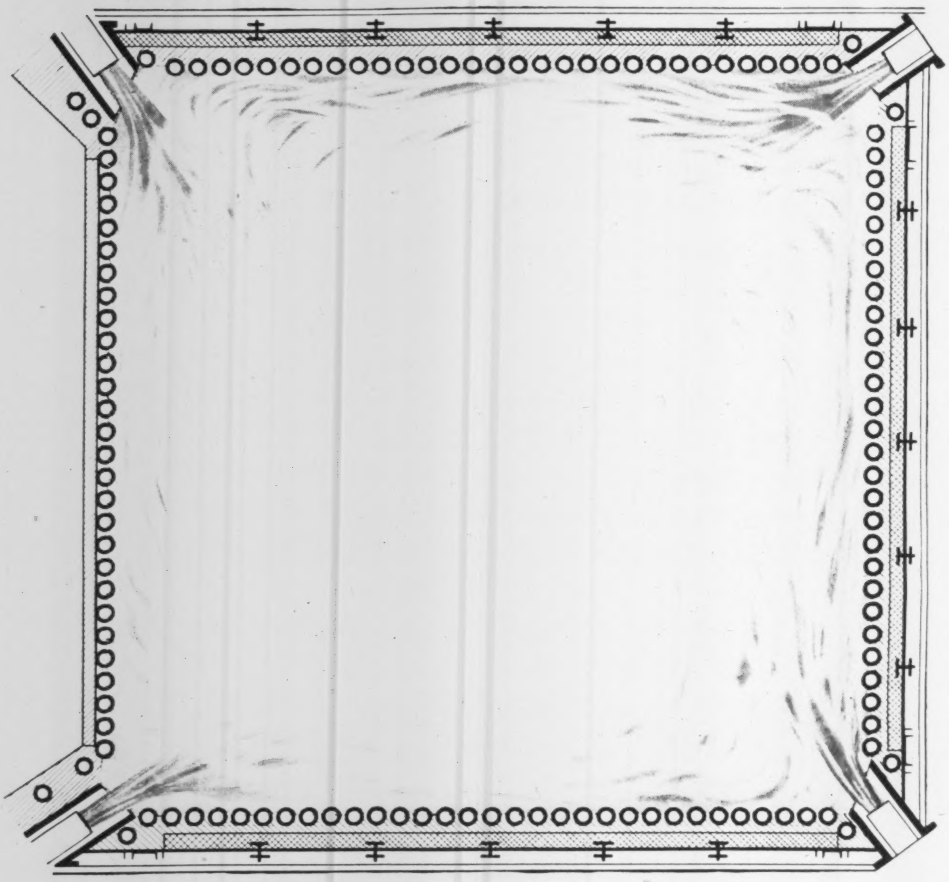
MECHANICAL ENGINEERING

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

November 1931



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What It's All About

HEEDING too blindly the biblical admonition not to let our right hand know what our left hand doeth, led us last month into an annoying error which most of our readers have been too forbearing to mention—at least to us. For having called attention in two places to a description of the Malone liquid engine that had been scheduled for the October Survey, we discovered too late that its appearance had been postponed to the November issue because of lack of space. The article in question appears, believe it or not, on page 825 of this issue. Editorial comment on the new engine will be found in the October issue on page 770.

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GOOD friends of ours in England, Mr. and Mrs. Vowles, who contributed an article on an early engineer-king of Mesopotamia some months ago and whose recently published book, "The Quest for Power," we shall have the pleasure of reviewing in an early issue, have prepared for MECHNAICAL ENGINEERING a brief biographical sketch of Jacob Perkins, an American engineer and inventor who died more than eighty years ago. Recent interest in critical-pressure boilers has given prominence to Jacob Perkins for his high-pressure "flash" boiler, developed between 1823 and 1827. Perkins has many other inventions to his credit, notably a method of engraving bank notes to make counterfeiting too difficult to be profitable.

:: :: ::

SINCE Perkins' experiments in high-pressure boilers a steady evolution toward their adoption has been going on. This month's Survey contains several indications of recent progress in power-plant engineering, such as a résumé of twenty years of development in the famous Lakeside Station, the installation of single-pass boilers in stations in Minnesota and West Virginia, the action of hydrogen on coal, and the fuel problems and practices of Great Britain.

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PROGRESS in engine design is reported in the description of the Junkers "Jumo 4" heavy-oil aircraft engine, a two-cycle design having opposed pistons. Further comment on this and other types of two-cycle portable Diesel engines will be found in the Survey, where there is also an abstract of comment on aeronautical engines displayed at the National Aircraft Show.

A RECENTLY accomplished engineering feat of major importance has been the building of New York's Eighth Avenue Subway, soon to be put in operation. Members of the engineering staff responsible for the design of the new subway have collaborated with us in an article describing some of the features that will most generally interest mechanical engineers. A second article will appear shortly.

:: :: ::

WHILE subway design and construction are primarily of interest to civil engineers, many problems involved and much machinery and equipment belong in the field of mechanical engineering. Problems in vibration damping are also of interest to civil and mechanical engineers, as will be evident from an excellent technical paper on the elastic mounting of vibrating machines which appears generously abstracted for easy reading in the present issue.

:: :: ::

EXPERIMENTAL work which must be carried on to give value to analytical studies of engineering problems calls for correctly designed and accurate instruments such as thermocouples for temperature measurements. Certain factors in the technique of designing and using thermocouples are discussed in an article to be found in this month's issue. Still another type of instrument, one for making humidity determinations, is dealt with in a preliminary draft of the A.S.M.E. Power Test Code devoted to this subject.

:: :: ::

ASIDE from technological subjects, MECHANICAL ENGINEERING recognizes the engineers' interest in all phases of industrial management, in the economics of his profession, and in his general cultural development. A brief but illuminating article on fire protection in industry calls attention to management's responsibility in the matter. Some charts giving further data collected by the A.S.M.E. Committee on the Economic Status of the Engineer, whose report on 1930 Earnings of Mechanical Engineers appeared in the September issue, are presented this month. Following up Professor Plank's paper on engineering culture and the fusion of sciences into one superscience, published last month, a brief digest of General Smuts's scientific world picture, presenting his theory of "holism," has been prepared for the present issue.

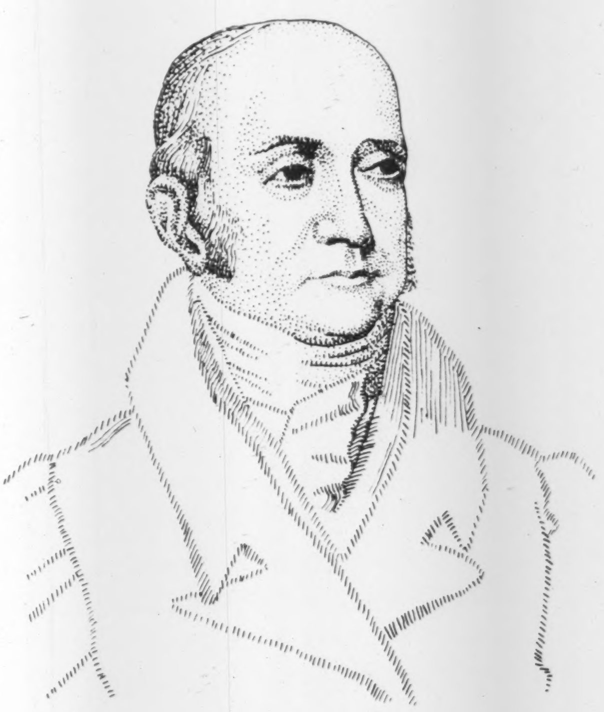
MECHANICAL ENGINEERING

Volume 53 November, 1931 No. 11

Jacob Perkins, 1766-1849

A Study in American Ingenuity and Intrepid Pioneering

By HUGH P. VOWLES[1] and MARGARET W. VOWLES,[2] LONDON, ENGLAND



Jacob Perkins
(After an engraving in Stuart's "Anecdotes of Steam Engines," 1829.)

THE name of Jacob Perkins is seldom heard today, though a hundred years ago he was justly regarded by many of his contemporaries as a brilliant mechanical genius and inventor. For some inscrutable reason he is now referred to with extreme brevity in many biographical dictionaries, while some do not mention him at all; and we note not without regret that the paragraph formerly devoted to his career in the "Encyclopaedia Britannica" has vanished from the latest edition. We do not intend, however, to dwell upon this tendency to neglect the memory of a man of whom both Americans and Englishmen have every reason to be proud. Our purpose at this time is rather to present a brief outline of his life and work, based as far as possible upon documents published while the inventor was still living.

Jacob Perkins was born in Newburyport, Mass., on July 9, 1766. His earliest known ancestor is said to have come from Newent, near Gloucester, England, having emigrated to Massachusetts in 1631. Of the first ten years or so of Jacob Perkins' life little is known, though we do know that he began to give evidence of his initiative and great inventive ability at an unusually early age. While still a boy he was employed by a goldsmith; and on the death of his employer in 1780 Perkins himself carried on the business, although at that time only fifteen years of age.

It is on record that young Perkins produced many novel and pleasing design in gold beads and work of a similar kind, and that when he was 20 or thereabouts he invented a method of plating shoe buckles. Shortly after this, in 1787, he was employed by the State of Massachusetts in making dies for copper coinage. The old Massachusetts cents, stamped with the Indian and the eagle, now only known to collectors and others interested in old coins, were produced by him. He soon found, however, that there was little future for him in such work. For it was in this year that the United States became a nation; and the right of individual states to issue coinage—retained hitherto under the Articles of Confederation—was transferred by the Constitution to Congress. Perkins thereupon applied his inventive genius to other projects, one of these being a machine for cutting and heading nails in one operation. This invention involved him in a lawsuit extending over a period of seven years. The first of his machines was erected at Newburyport, but subsequently he installed one at Amesbury, where he built a mill, the motive power for which was derived from a waterwheel. This was about the year 1790. Either then or perhaps a little later he appears to have been involved in considerable financial distress; though this was due to the mismanagement of his partners rather than to any fault of his own. Thereafter came some years of hardship, which he faced with characteristic courage and determination. "The strong man and the waterfall," says an old proverb, "channel their own path." In this respect, as we shall see, Perkins resembled the waterfall.

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[1] Engineer and Author. Mem. A.S.M.E.; M.I.Mech. E., Assoc. I.E.E.

[2] B.Sc. (Lond.); Mem. History of Science Society.

Perkins' Method of Engraving Bank Notes

After living in Boston and New York, he moved to Philadelphia in 1814, where he came in contact with a bank-note engraver, Gideon Fairman, of the firm of Murray, Draper, Fairman & Co. It would seem that during the intervening years Perkins had continued to think about the technical problems arising out of the issue of money. But now it was the issue of paper money that occupied his thoughts. Certainly in those days there were enough formidable problems due to ill-regulated issues of paper money, and to defective methods of printing it, to attract the attention of thoughtful men on both sides of the Atlantic. "The early history of paper-money banking in the United States," remarked the American economist, Francis A. Walker, "is not pleasant reading."[3] As for other countries, it will suffice to mention that the leading banks of England, Ireland, Portugal, Prussia, Austria, Venice, and Genoa, all suspended payments in cash between 1797 and 1801, while a large number of smaller banks had already been involved in serious difficulties or had gone under altogether. The world was flooded with paper money in consequence, and counterfeiters on both sides of the Atlantic were not slow to take advantage of the situation. It has been well said that the ease with which the clumsy engravings of the day were imitated was a temptation to every knave who could scratch copper.[4] The death penalty, which was inflicted in most European countries for this offence, had little deterrent effect. Here, then, was an opportunity for Perkins to exercise his ingenuity. With the resourcefulness which he displayed on so many occasions, he devised a method of engraving bank notes which, in the words of a claim made on his behalf, was "essentially founded upon the assumption that the bank note may be made to contain so great a quantity and variety of work, extremely difficult of imitation, that a single note so made would cost the counterfeiter more than he could obtain by passing several hundreds of them."[5] In the same document it is stated that his method was invented in 1805, and in 1809 was adopted by most of the banks in New England and elsewhere in the United States.[6]

Not only was steel substituted for copper in this process, but Perkins devised a method for making copper and steel facsimiles from the original. In its early stages the process involved the production of a number of small wrought-iron bars each about 3 in. long and $^1/_2$ in. square, which when assembled would make a plate about 12 in. square and $^1/_2$ in. thick. So difficult was it in those days to procure iron without flaws and suitable for engraving upon, that a ton of iron bars had to be cut up before sufficient material for one plate could be obtained. The small pieces of iron were nicely fitted together, assembled in a frame, polished on one surface, and then elaborately engraved with steel punches and graving tools, every portion of the plate being covered with small figures and letters. The pieces were then case-hardened after being removed from the frame. It will be obvious that the pieces could then be reassembled in a variety of combinations; and that by varying the order of assembly, variations in the design printed from the plate could be obtained which would enormously increase the difficulties of the counterfeiter.

Subsequently Perkins used steel instead of wrought iron. His revised process was described by himself as follows:

> Before steel can be cut by the graver it requires to be softened, by depriving it of a portion of its carbon, which is effected by imbedding the steel to the depth of half an inch on all sides in a bed of pure iron filings, contained in a cast-iron box with a well-closed lid. In this box the steel is to be exposed for four hours to a white heat, after which it is to be suffered to cool very slowly, which is best effected by shutting off all access of air to the furnace, and covering the box with a layer of fine cinders to the depth of six or seven inches. After the steel plate has been engraved, it requires to be hardened or reconverted into steel.

He then goes on to describe the rehardening process. Following this the surface of the plate was cleaned, "and the temper finally reduced by heating it over a fire, until it acquires such a shade of color as denotes that the steel is of the fit quality for the required purpose."

Facsimiles were produced in the following manner. A cylinder of soft steel, about 3 in. diameter, was rolled to and fro across the engraved plate until the whole of the impression was seen on the cylinder in relief. The cylinder was then hardened, and rolled across a plate of copper or soft steel until a perfect facsimile of the original was produced, having practically the same sharpness of definition. Referring to this as a truly wonderful invention, the editor of the "Mechanics' Encyclopaedia," writing in 1835, remarks:

> At the present time the notes of most of the provincial banks in this country are produced by this process, some of them presenting the most beautiful specimens of the art of engraving ever witnessed. The Bank of England, however, has declined availing itself of the advantages which the plan holds out, and after going to the expense of more than £30,000 in endeavoring to improve the quality of its notes, and to render them more difficult of imitation, still continues to issue the same wretched description of notes as have been so extensively and successfully counterfeited for many years past."[7]

Attempt to Exploit Bank-Note Engraving Process in England

We have, however, gone ahead a little too quickly, and must now return to the time when Perkins was still in Philadelphia and had come in contact with Gideon Fairman—that is, in 1814. During the next few years the two men devoted their energies to the exploitation of the process in America. But in the year

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[3] Walker, "Money in Its Relations to Trade and Industry," p. 300.

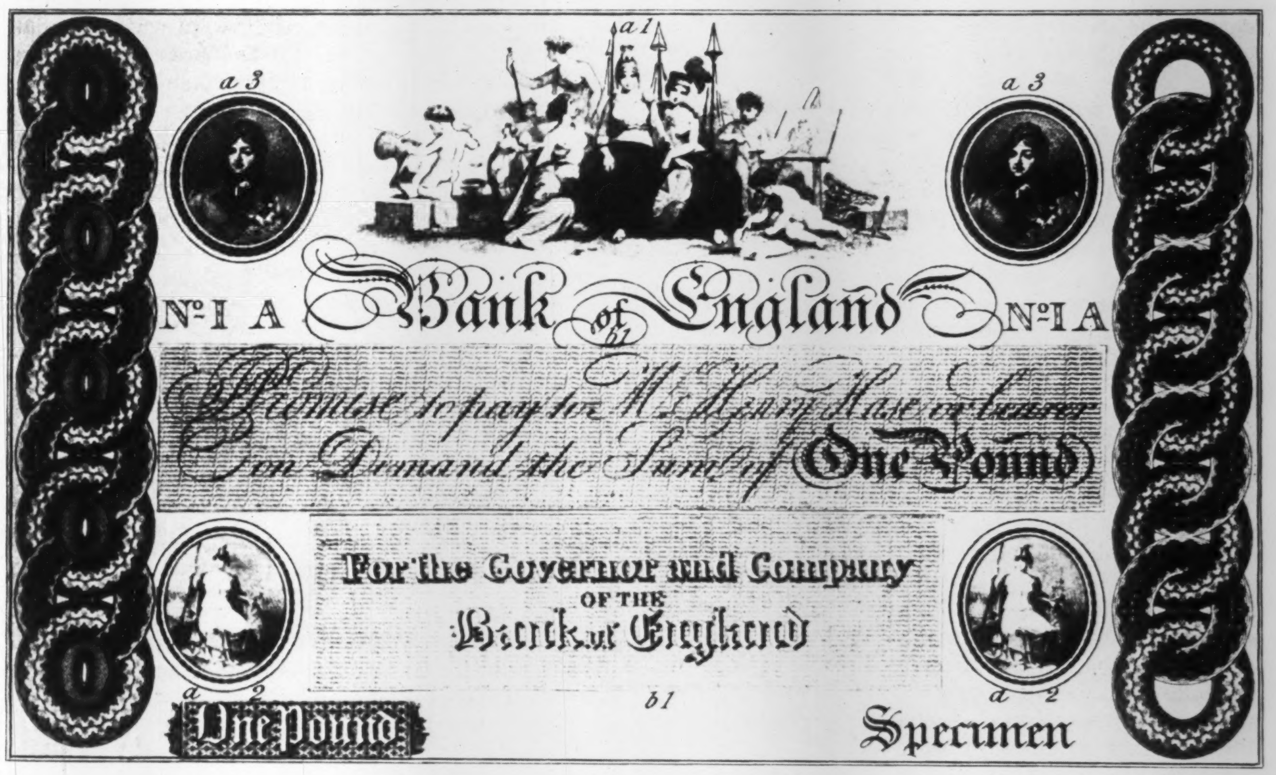
[4] "The variety of laws and the loose and often unscrupulous practice under them in different States led to the issue broadcast of a vast variety of notes. . . As a result many counterfeit and spurious notes and those of insolvent banks floated about and vitiated the currency." —A. K. Fiske in "The Modern Bank," New York, 1904.

[5] "Specimens and Description of Perkins's and Fairman's Patent Siderographic Plan to Prevent Forgery," London, 1819.

[6] We believe that the State of Massachusetts passed a law compelling banks in that state to adopt the form of note invented by Perkins.

[7] "Mechanics' Encyclopaedia," London, 1835, pp. 475, 476.

1818, accompanied by some of their workmen, they crossed the Atlantic,[8] Perkins having been advised by Sir Charles Bagot, British Minister to the United States, to proceed to England and compete for the contract for Bank of England notes then about to be given out. They completed the journey about June, 1818, bringing with them some 26 cases of machinery. Having set up their plant in Fleet Street, London, they made a determined effort to secure the Bank of England contract. But in this, as already indicated, they were not successful. Not only did they meet with apathy on the part of the Bank authorities, but also with considerable opposition from another quarter. Two English inventors, Applegath and Cowper, now put forward a process which they claimed should have preference over the ideas of men who were foreigners, and had lately been enemies of Britain.[9] So far as we have been able to trace, there was nothing in the Englishmen's proposal beyond the fact that Cowper had already made considerable improvements in the printing press, having in 1815 taken out a patent for curving stereotype plates so as to fix them to a cylinder. Twelve of these machines were supplied to the Bank of England. We do not know, but feel justified in surmising that much hard work was involved in obtaining the order for these machines, having regard to the reputation of the Bank officials of that time. Though men of undoubted integrity and character, these officials were singularly unintelligent, obstinate, opinionated, and opposed to innovation. In 1810, for example, they were cross-examined by a Parliamentary Committee as to the reasons governing their issues of paper money; and, says Walter Bagehot, "gave answers that have become almost classical by their nonsense.[10] Nevertheless the Perkins "Plan" had so much in its favor, and had such influential support, that Applegath and Cowper could but view with concern the determined efforts of the Americans to secure its adoption. It is to the credit of a number of eminent English engineers of that time that they completely disregarded the agitation against "foreigners," and judging the rival methods on their merits, signed a statement supporting the claims of Perkins and Fairman. Among those who thus lent the prestige of their names were George Rennie, Bryan Donkin, Mark Isambard Brunel, Henry Maudslay, and Joshua Field. But Cowper and his partner need


a 1
a 3
a 3
Nº I A
Bank of England
Nº I A
I Promise to pay to Mr. Henry Hase or bearer
on Demand the Sum of One Pound
For the Governor and Company
OF THE
Bank of England
a 2
One Pound
b1
a 2
Specimen

Courtesy of the British Museum

Specimen One-Pound Note Designed and Printed for Submission to the Bank of England by Perkins and Fairman
(From "Specimens of Perkins's & Fairman's Plan to Prevent Forgery," 1819.)

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[8] Before leaving Philadelphia, Perkins and Fairman had signed a three-year agreement with Asa Spencer, inventor of the geometric lathe, according to which Spencer was to proceed to England and produce for them the white-line machine engraving which was a feature of the Perkins bank notes, a portion of one of the designs of which was subsequently used in the back ground of the penny postage stamp.

[9] Peace between the United States and Britain had been declared in December, 1814.

[10] Walter Bagehot, "Lombard Street," 1920 ed., p. 167. Macleod, in his "Theory and Practice of Banking," declares that the directors were not competent to manage their own business.

not have been alarmed. Sir W. Congreve and his associates at the Bank would have nothing to do with Perkins' invention; and, it may be added, the notes of the Bank of England for £5 and upward are to this day printed in much the same manner as they were 200 years ago, protection against forgery now being largely dependent upon the water mark and periodical modifications in the numbering.

First Penny Postage Stamps Produced by Perkins' Firm

Nevertheless Perkins, as indicated above, was supported by the country banks; and with the help of the capital and influence of the Heath family, he established a factory for making plates and printing bank notes. George and Charles Heath, with whom the two Americans became associated, were sons of the then Engraver to the King, James Heath, R.A. The firm commenced trading in 1819 at an old building in Fleet Street, now pulled down, as Perkins, Fairman, and Heath. Subsequently a printer named Joshua Butters Bacon married the daughter of Jacob Perkins, and Gideon Fairman having returned to America in 1822, the trading title was altered to Perkins, Bacon, and Company. Before the death of Perkins this firm was entrusted with the production of the first penny postage stamps, introduced by Rowland Hill in 1840. In the following forty years the firm produced over twenty-two thousand million British postage stamps by the process invented by Jacob Perkins, besides many of the old classic stamps of the British Empire and of other nations, treasured today by stamp collectors the world over. It is of interest to add that the firm of Perkins, Bacon & Company, Ltd., still carries on a flourishing business as bank-note and stamp engravers in Southwark Bridge Road, London. To a director of this firm, Mr. John M. Heath, a grandson of Jacob Perkins' partner, the authors are indebted for several valuable additions and corrections to this article.

Boiler Designed by Perkins to Generate High-Pressure Steam

But again we have gone ahead too quickly, and again must return—this time to the days when Perkins was first embarking on a career in London. Although he succeeded in establishing a business, he still found himself faced with difficulties and disappointments which might well have crushed a man with less determination and force of character.[11] Nevertheless he now found time to develop other ideas which had been maturing in his fertile brain, notably in connection with the possibilities of high-pressure steam. With the exception of one or two men like Trevithick, Vivian, and Woolfe, English engineers had up to this time fought shy of experimenting with steam at more than a few pounds above atmospheric pressure. Now, in 1823, at the age of 57, Perkins began a series of remarkable experiments with steam which startled the British engineering world by their novelty, and the evidence they afforded of the fearless pioneering spirit which animated the American inventor. Many of these experiments were carried out with plant installed in a smithy in Water Lane, Fleet Street, London, close by the bank-note engraving works. One of his steam boilers consisted of a vessel of copper 3 in. thick, marked *A* in Fig. 1. An outlet at *B* communicated with a pipe *G* leading to the engine cylinder. This outlet was normally kept closed by a valve loaded by an adjustable weight on an arm, in the manner of a safety valve. An inlet pipe *C* connected the vessel with a small force pump *D*, the handle of which was loaded by a weight *E*. A pipe *I* led to a gage which indicated the pressure in the copper vessel. The water in this vessel was subjected to hydraulic pressure, and while in this condition was submitted to the highest possible temperature obtainable by forced draft. No steam was generated in the vessel itself; but when the pump forced a small quantity of cold water into it, the escape valve opened, allowing an equal quantity of heated water to escape. This was instantly flashed into steam, which was conducted through the connecting pipe to the engine cylinder. In 1827 Perkins attained to working steam pressures of from 800 to 1400 lb. per sq. in. with this apparatus.

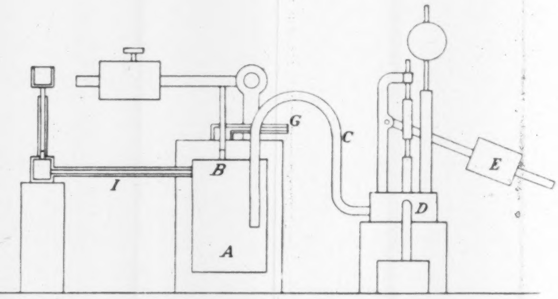

Fig. 1 Perkins Boiler as Illustrated in "Anecdotes of Steam Engines," 1829

Similar experiments were carried out with another boiler consisting of a series of cast-iron bars, 5 in. square, each perforated longitudinally with a hole $1^{1}/_{2}$ in. in diameter. These bars, or tubes, were arranged in three tiers, *A*, *B*, and *D*, Fig. 2, across a furnace; the ends being connected so as to form, in effect, one continuous tube. The connection between the bottom tier and those above it, however, was ordinarily kept closed by means of a valve. A force pump was used to inject water as before, under pressure of a heavily loaded valve, the two upper tiers *A* and *B* being kept always full by this means. The lowest tier *D* contained no water, and was maintained by the furnace at a temperature of about 1000 deg. fahr. At each stroke of the engine a quantity of water from the upper tiers (said to have been kept at a temperature of about 800 deg. fahr.) was discharged through the check valve into the lowest tier *D*, where it was flashed into steam. From the tubes the steam passed into a receiver *L*, from which it was led through the pipe *H* to the engine.

---

[11] Among other obstacles he had to overcome the passive resistance which opposes, often through motives of personal jealousy, many of those who seek to advance the frontiers of human knowledge and accomplishment.

Perkins naturally had great difficulty for some time with cylinder lubrication when working at high pressures. Eventually, however, he claimed to have overcome this difficulty by using a special alloy for the piston, which became so highly polished as to require no lubricant.

THE STEAM GUN

It is impossible to give here full details of the numerous other experiments made by this remarkable mechanical genius. Mention must be made, however, of his steam guns, the effectiveness of which he demonstrated before the Duke of Wellington and other military celebrities of the time.[12] One of his demonstrations consisted in firing balls which passed through eleven planks, each 1 in. thick and placed 1 in. from each other. He also constructed a model of a steam machine gun; and by screwing a gun barrel to a tube filled with balls, showed that it was possible to discharge them at the rate of nearly 1000 a minute. For an engine designed for marine propulsion in 1827, Perkins proposed to use steam expansively at a pressure of 2000 lb. per sq. in. In 1829 he took out a patent for an improved paddle wheel, and in 1831 invented a method of securing free circulation of water in boilers which led the way to the development of the modern water-tube boiler (see Fig. 3).[13]

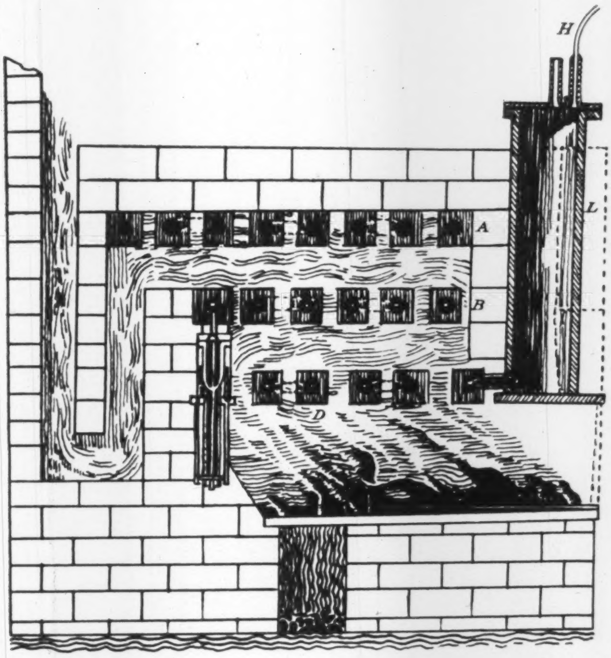

FIG. 2 PERKINS BOILER AS ILLUSTRATED IN THE MECHANICS' ENCYCLOPAEDIA, 1835

OTHER INVENTIONS

Some years earlier, in 1820, Perkins had been elected a member of the Institution of Civil Engineers. Subsequently he contributed several papers on the elasticity of steam, one on steam boilers, and another, read by him in 1837, dealing with steam raising in locomotive boilers. In the latter paper he suggested the use of superheated steam—or "steam surcharged with caloric," to use his own words—and also recommended the manufacture of engines with interchangeable parts.

In 1820 he had also given to the Society of Arts in London full details of several other inventions, including a method of warming and ventilating rooms, ventilating the holds of ships, and a method of fastening the seams of hose for fire engines. For these and other inventions he was awarded the Gold and Silver Medals of the Society. In 1826 a paper of his was read before the Royal Society in which he gave an account of experiments demonstrating the compressibility of water; showing how he had reduced water by 1/11.5 of its volume under a pressure of 2000 atmospheres.[14] For the purpose of measurement in this connection he used an ingenious instrument of his own devising. Other inventions included a bathometer for ascertaining depths, and a "plenometer" to indicate the speed of vessels moving through water.

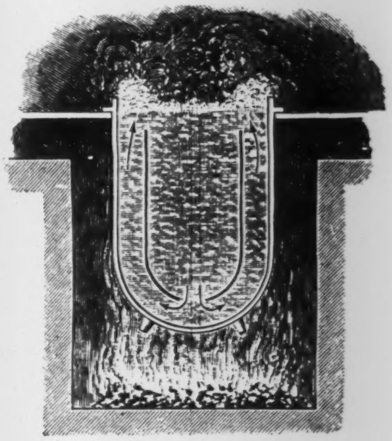

FIG. 3 DEVICE INVENTED BY PERKINS IN 1831 TO IMPROVE BOILER CIRCULATION

(Reproduced by permission from page 27 of "Steam," issued by the Babcock & Wilcox Co., New York, and Babcock & Wilcox, Ltd., London.)

AN INVENTOR IN ADVANCE OF HIS TIME

Though it will be seen that Jacob Perkins received recognition in various quarters, there can be no doubt that he paid the penalty of being in advance of his time. He was a pioneer; and it has only too often been the lot of the pioneer to be misunderstood and derided by those who are animated by no higher ideal than to take—and leave—the world as they find it. To such as these the pioneer who has not reaped the reward of his labors can only say:

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[12] In 1861 A. M. Perkins (who like his father remained all his life a loyal citizen of the United States, though domiciled in England) endeavored to persuade President Lincoln to adopt the use of an improved form of the steam gun. A letter supporting this proposal, addressed to Abraham Lincoln and Simon Cameron (Secretary of War), was signed Oct. 15, 1861, by a number of eminent New York citizens, including the governor of the state, well-known merchants, bankers, and publishers, and various public officials of high standing. We do not know with what result, but suspect that the idea was not adopted.

[13] See address by George H. Babcock, delivered at Cornell University, February, 1890.

[14] "On the Progressive Compression of Water by High Degrees of Force," Trans. Roy. Soc., June, 1826.

We know the price, and yet our gifts we strew,
Our lifeblood and our tears to feed the lamp
God orders us to bear in front of you.

In conclusion we cannot do better than quote the words of one who knew Jacob Perkins personally, and was able to form a just estimate of his rare combination of genius and character. We refer to the British engineer Robert Meikelam, who wrote on the history of the steam engine under the name of Robert Stuart:

> In looking at Mr. Perkins' labours, the mass of prejudice with which he has been and continues to be assailed forcibly arrests attention. Keeping the great value of his experiments totally out of view, his is no small share of merit for the steadiness of purpose with which he has borne up against the interests and spleen arrayed against him; for it cannot be concealed that his exertions have been spoken of in terms both contemptuous and harsh, although throughout they have been of that laudable and meritorious kind, that even failure in them should have brought him honour.... One thing is certain, that viewing his exertions from first to last, no other mechanic of the day has done more to illustrate an obscure branch of philosophy by a series of difficult, dangerous, and expensive experiments.[15]

With unconquerable courage and perseverance Perkins continued at work until nearly 70 years of age. Thereafter he lived in well-earned retirement, the engineering business which he had built up being carried on by his sons.[16] He died in London, England, on July 30, 1849. Of his two sons, one, Angier March Perkins, also born in Massachusetts, inherited some of his father's inventive powers, and was well known in his time as an engineer of considerable ability. A grandson, Loftus Perkins, who died in 1891, also made a name for himself in the engineering world.

Early Physics Research in Great Britain

IN SPITE of the fact that until the end of the last century there were but few laboratories available for research, much scientific work of the highest importance was accomplished. This, to a very great extent, was due to men who made their own laboratories and bore themselves the cost of the experiments. Thus, Joule made his experiments on the mechanical equivalent of heat in his house at Manchester; Stokes, like Newton, made fundamental experiments on optics in his college rooms; Spottiswoode, Huggins, De la Rue, Lord Rayleigh, and one who has had a long and intimate connection with the British Association—Dr. E. H. Griffiths—also made in their own laboratories and at their own charges additions of great value to physical science.

These men, like Kelvin and Maxwell, had not passed through any course of instruction in practical physics, for no such courses were available; they were in this respect self-taught. Most of them had learned how to use their hands by having had when young some hobby, such as using a lathe, or dabbling in chemical experiments or photography. This training seems to have been effective, for no one can say that their work is amateurish. This raises the important question, may not the present practice in which our advanced students spend a great deal of time in acquiring dexterity in the use of instruments of all kinds be a wasteful one, and could not the student who has learned how to use his hands, has a good knowledge of physics and some practice in making accurate measurements, be trusted to master in a short time the technique of any instrument he might require in a special investigation?

In the early seventies when I first began to study physics at Owens College, Manchester, there were only six physical laboratories in England, four in Scotland, one in Ireland, and none in Wales. Now the number of physical laboratories at the universities, university colleges, schools, and institutes of technology at which instruction is given in physics, is considerably more than 300. Some of the laboratories in those early days were very small affairs. Professor Ayrton described Sir William Thomson's laboratory at Glasgow as consisting at one time of one room and an adjacent coal cellar. When I was at Owens College, Manchester, though it was one of the first places where instruction was given in practical physics, there was no separate laboratory, but only a few rooms and little apparatus. Though the laboratory was small, it was large enough for the few students who worked there, and these had much more freedom and more initiative than would be possible with the large number of students that have now to be provided for. We were allowed to choose our own experiments, we fitted up the experiments for ourselves and if they did not work we tried again; we were not limited with respect to time, and we could follow up any point of interest we happened to come across. This rather happy-go-lucky method would be quite impossible with large classes, but it was more interesting and, I think, a better training for research than the highly organized classes which large numbers necessitate. At any rate, I am glad that I came under the old and not under the new system. The new method, however, besides being inevitable, has some very decided advantages. There are students who are quite immune when in the lecture room to infection from any physical idea, and only get a grip of physical principles when these come before them in the concrete form of an experiment which they make with their own hands; these men learn their theoretical as well as their practical physics in the laboratory, and the nature of the experiments, their number, and their sequence are of first-rate importance.—Sir J. J. Thomson in presidential address before Section A, British Association for the Advancement of Science, London, September, 1931.

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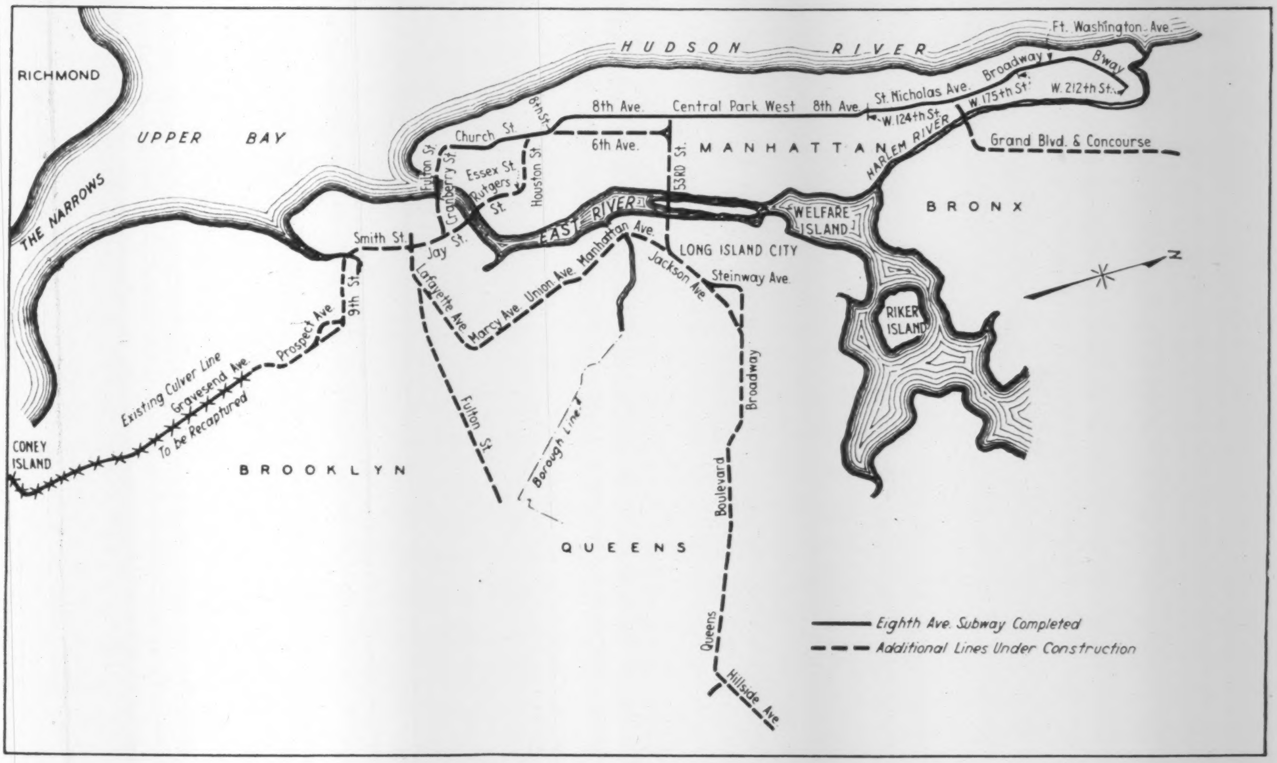
[15] Stuart, "Anecdotes of Steam Engines," London, 1829, p. 605.

[16] The bank-note and postage-stamp engraving business was managed eventually by Jacob Perkins Bacon, the son of Joshua Butters Bacon and Jacob Perkins' daughter. J. P. Bacon died in 1889.


RICHMOND
UPPER BAY
THE NARROWS
HUDSON RIVER
Ft. Washington Ave.
Broadway
B'way
W. 212th St.
W. 175th St.
St. Nicholas Ave.
W. 124th St.
8th Ave.
Central Park West
8th Ave.
8th St.
Church St.
6th Ave.
MANHATTAN
HARLEM RIVER
Grand Blvd. & Concourse
BRONX
Fulton St.
Cranberry St.
Essex St.
Rutgers St.
Houston St.
53RD St.
EAST RIVER
WELFARE ISLAND
Smith St.
Jay St.
Manhattan Ave.
LONG ISLAND CITY
Steinway Ave.
Jackson Ave.
Lafayette Ave.
Marcy Ave.
Union Ave.
RIKER ISLAND
9th St.
Prospect Ave.
Existing Culver Line
Gravesend Ave.
To be Recaptured
CONEY ISLAND
BROOKLYN
Fulton St.
Borough Line
Broadway
Boulevard
QUEENS
Queens
Hillside Ave.
N
Eighth Ave. Subway Completed
Additional Lines Under Construction

New York City's New Subway System

New York City's Eighth Avenue Subway[1]

First Section of City's New Rapid-Transit Routes to Be Operated Comprises 12.3 Route Miles and 53.8 Track Miles of Subway—Some Outstanding Mechanical Features of the Construction and Equipment

In 1924 the Board of Estimate and Apportionment of the City of New York approved plans submitted to it for the construction of a comprehensive system of new rapid-transit routes. The first step of this new subway system embraces 55.5 route miles and 182.5 track miles, its extent being shown by the accompanying map. The Eighth Avenue Subway, the first section to be completed, comprises 12.3 route miles and 53.8 track miles, and was begun in March, 1925. All details of the design and construction have been carried out by the Board of Transportation.

While this section comprises less than one-quarter of the total route mileage of the first step now under construction, it will help nevertheless immensely in relieving present congested transit conditions. It extends along the entire west side of Manhattan and taps the Washington Heights district, which is now served principally by the Seventh Avenue Subway of the Interborough Rapid Transit Company. It has stations at 175th and 181st Streets near the Manhattan end of the new Hudson River bridge. These should serve as convenient terminals for bus lines operating over the bridge into New Jersey. It crosses the Seventh Avenue Subway at Columbus Circle (59th Street), which should be a convenient transfer point for uptown passengers, and a connecting passage is provided to the Hudson Terminal at Church Street. When the additional lines are completed there will be connections to lines to the Bronx, to Jamaica, and to Brooklyn.

The Eighth Avenue Subway has four tracks from Chambers Street to 168th Street, and two tracks from 168th Street to 207th Street. It is estimated that about 5,000,000 passengers will be carried the first month of operation. A table on page 792 gives additional data and comparisons with existing lines.

Some Outstanding Engineering Problems Encountered in Constructing the Subway

Many of the methods used in the construction of the Eighth Avenue Subway compel the attention and admiration of all engineers. One particularly difficult

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[1] Prepared from information furnished by the engineers of the Board of Transportation, New York City.

SOME STATISTICS ON NEW YORK SUBWAY LINES

Interborough subway lines, track miles	223
Interborough elevated lines, track miles	118
Total Interborough track miles	341
B.M.T. subway and rapid transit, track miles	123
B.M.T. older elevated lines, track miles	150
Total B.M.T. track miles	273
Eighth Avenue Subway—207th Street to Chambers Street:	
Route miles	12.3
Track miles	53.8
Total present rapid-transit lines, track miles	614
Percentage Eighth Avenue line is of total rapid-transit lines	8
Number of tracks, Eighth Avenue subway (omitting flexing tracks and sidings):	
Chambers Street to 168th Street	4
168th Street to 207th Street	2
Number of stations, Chambers Street to 207th Street:	
Locals only	13
Branch stations either local or express	5
Regular 4-track express	10
Total	28
Average distance between stations in feet:	
168th Street to 207th Street (2 tracks, 12,400 ft., 5 runs)	2480
168th Street to Chambers Street:	
Express (51,200 ft., 9 runs)	5689
Local (51,800 ft., 22 runs)	2355
Construction work started	March, 1925

place for carrying on construction work was at Columbus Circle, where the new subway lines pass underneath the four-track Interborough subway. A four-track station was constructed at that point in a rock cut about 220 ft. long by 135 ft. wide. The crossing was made at an angle of about 40 deg., and there was but from 6 to 12 in. clearance between the roof of the new subway and the bottom of the old. The principal operations in this construction included: providing temporary support for tracks; shoring columns; changing, protecting, and maintaining service for signals, lights, switches, telephones, etc.; drifting under the Interborough structure; setting underpinning girders on cribs; transferring track-floor and column loads to girders; shoring girders to rock at subgrade; completing excavation to subgrade; erecting 300 tons of heavy structural steel; and transferring the Interborough subway and its loads to the new structure.

The Columbus Monument at that point was underpinned separately. Drifts were run under the base and built-up girders placed in them. These were underpinned with concrete columns placed in 5-ft. × 5-ft. rock shafts sunk below subgrade. As the rock was blasted out around them, additional heavy steel columns were placed to give support to the structure.

Several unusual problems were encountered at the crossing underneath the subway lines of the Center Street loop. The Essex Street station of the old lines is supported for an area of 20,000 sq. ft. on the Schiff Parkway station of the new Essex Street subway which connects to the Eighth Avenue Subway at Houston Street. The old subway is 25 ft. below the street, and the new subway, 45 ft.

Unusual problems were encountered as (1) there was an extremely large area of old subway to be supported (20,000 sq. ft.); (2) the base of the rail of the existing subway was at groundwater level; (3) the soil was of very slow drainage; (4) the old subway was of very irregular construction, being a remodeled trolley subway with variable structural-steel supports; and (5) the floor and walls of the old subway were in very poor condition due to water at track level and settlement in the soil.

The work was done without interfering with operation and without settlement of the old subway. In doing the work the contractor:

1 Drew down the water to a level 10 ft. below the old subway by open shallow pumps.

2 Drifted through in 10-ft.-wide drifts 8 ft. deep, and set long continuous-girder beams to form a roof for the new subway.

3 Jacked down steel piles 25 ft. below the new subgrade to carry the continuous girders.

4 Completed the excavation from the center toward the sides, draining the ground in stages with drainage ditches.

5 Jacked in a run of piles with 4-ft. centers along the outside lines to carry horizontal sheeting.

6 Concreted a 4-ft.-thick wall at the sides to form the side wall of the new subway.

7 Placed a reinforced-concrete invert designed to throw all the load on the piles which were concreted in the floor, collars having been welded on the piles to carry the load.

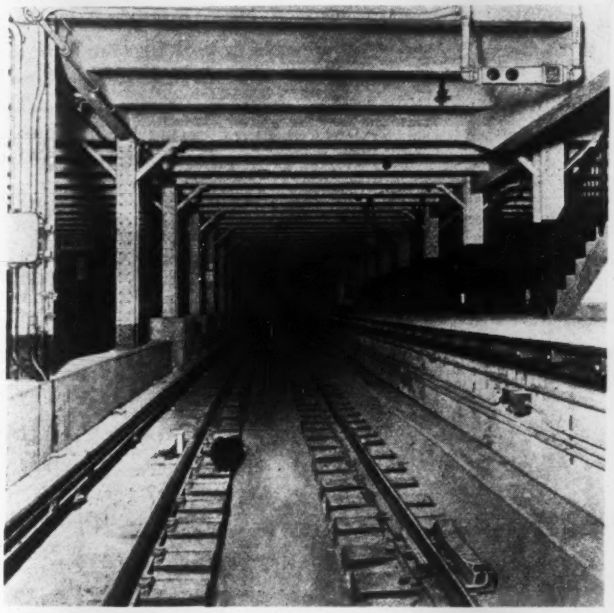
8 Erected the remainder of the structural steel and group-jacked the design loading in each grillage to take the load directly on the steel from the temporary extension of the piles above the floor.

SUPPORTS FOR ELEVATED RAILWAYS COMPLICATE CONSTRUCTION

A considerable length of the new subways is underneath existing elevated railways. Vertical columns supporting these have masonry footings from 5 to 30 ft. below street level. In some cases they were directly over the subway structure, which had to be carried down to considerably below the footings. Many improved methods were developed for this work, which involved the excavation of pits carried down about 10 ft. each side of the columns. In these, sills, grillages, or foundation piles were placed to support pairs of piles or vertical timbers. The piles or grillages were capped at the street level to support columns or A-frames extending from that point to the elevated girders. The feet of the inclined supports were drawn together or spread apart by eyebars which were bolted to the feet. The tops of the supports could thus be raised or lowered as desired. Nearly every location had some special conditions to be met, and many labor-saving devices were resorted to.

IMPROVED METHODS FOR HANDLING MATERIALS

Materials-handling methods varied considerably with the different conditions encountered. Compressed air was used to a large extent both in construction work and materials handling. Electrically driven air compressors delivered air at about 110 lb. pressure to mains from 5 in. to 8 in. in diameter running the length of the section under construction. Electrical energy for light and power was purchased from supply companies, and most of the power machinery was operated by either gasoline engines or compressed air. Groundwater was removed from the deeper places by electrically driven centrifugal pumps. The trench method of construction was used where possible, but in most locations traffic conditions made it necessary to close the top of the trench with planking. At some intersecting streets, ramps were constructed so that motor trucks could handle the material from the trench. At other locations caterpillar-tractor cranes hoisted material through hatchways in the deck and dumped it into motor trucks.



Interior Construction of Eighth Avenue Subway at a Station

At some points where ramps could not be constructed, a pit was excavated and sheeted down to a depth of about 35 ft. A heavy steel framework was installed in this which carried a platform about 30 ft. above the street level. From this an electric hoist operated an elevator platform which was provided with automatic gates to protect the shaft from street traffic. Motor trucks were raised and lowered on the platform and were loaded by steam shovels.

A telpher plant for loading spoil at the road level proved very efficient. This was about 200 ft. long and 35 ft. high. Its two main trusses were supported by two four-wheel towers that ran on a track in the street. The trolley track was 30 ft. above the street level. The spoil was loaded by compressed-air shovels into 2-yd. skips, which were run on narrow-gage flat cars to the traveling telpher hoists. The loaded skips were hoisted above the street level and then transported to the ends of the telpher trusses, where the contents were dumped into motor trucks. As the work progressed the telpher plant was moved forward in 20-ft. stages so that the towers always rested on the transverse girders that were shored up to receive them. The upper part of the excavation was made with grab buckets operated by caterpillar-tractor cranes in the street. Deeper excavations were made by steam shovels.

Concrete for construction was usually mixed at a central plant, which in some cases was several miles from the job. In winter the mixing water was heated and the aggregate was warmed by steam coils in the storage bin. This enabled the concrete to be placed in forms 2 miles away at a temperature of 70 deg. when the outside temperature was zero. Concrete was transferred to the subway in motor trucks and discharged into large hoppers, from which it was distributed to forms, usually within 20 min. after mixing.

How the Stations Differ From Those on Previous Lines

Except as to length, the new stations of the Eighth Avenue Subway are similar in structure to the stations of other New York subways at the track level, as is shown by the accompanying table, but the mezzanines differ.

The mezzanines of most of the new stations extend the full length of platforms, while the old ones usually have small mezzanines which limit the station capacity in many respects. Wherever possible the new stations have free passageways leading usually to a center control. Secondary controls are provided at various points with high prepaid-entrance turnstiles. This arrangement not only makes it possible to have entrances at each street intersection, but permits approaches from private property without creating new controls. Furthermore, it provides a series of stairs to platforms which will prevent congestion on the latter because of outgoing passengers.

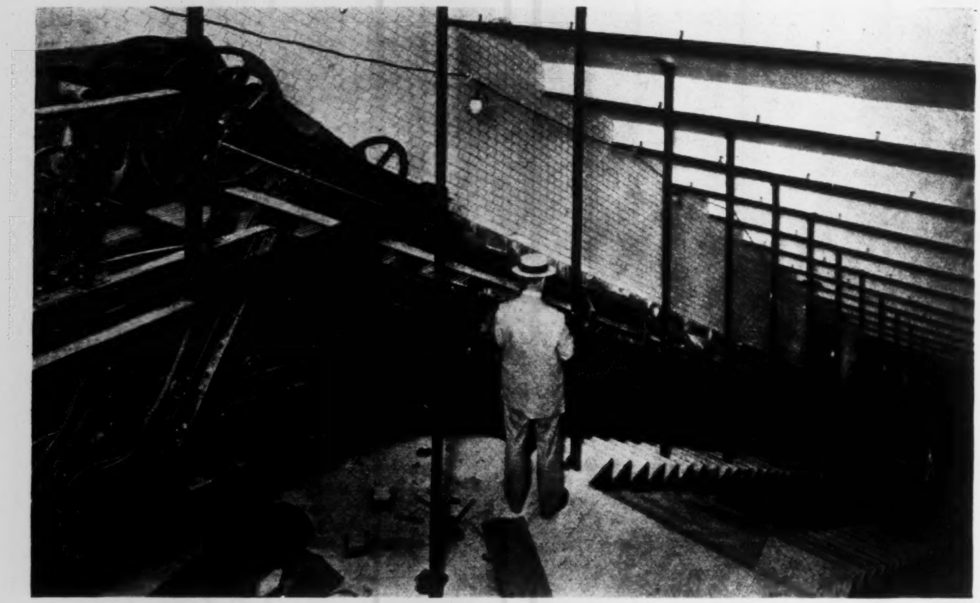
Comparison of New With Old Stations

	New stations	I.R.T.	B.M.T.
Length	600 ft.	480 ft.	510 ft.
Distance, center line of track to edge of platform	5 ft. 2 in.	4 ft. $9^1/_2$ in.	5 ft. 2 in.
Distance, base of rail to ceiling	13 ft. 2 in.	13 ft. 2 in.	13 ft. 2 in.
Width of side platform	12 ft.	8 ft. and 12 ft.	8 ft. and 12 ft.

Fares will be collected exclusively by means of pay-as-you-enter turnstiles, the operation of which is entirely mechanical. These will be of two sizes, generally spoken of as low and high types, and will resemble greatly those installed in the subways operated by the B.M.T. interests. The principal perceptible difference between these two machines and those operating at present is the fitting of silencers, which, in addition to reducing the noise of operation, also moderate the force of the blow which the turnstile arm gives just before the end of the stroke.

The turnstiles have also been designed to provide a mechanism of great ruggedness, by which it is expected that both the reliability of operation will be increased and the cost of maintenance reduced; also the force required to operate them will be a minimum.

At several stations there are public passageways in which space has been provided by the city for merchandise shops. At Columbus Circle the public passageway at the mezzanine level forms a sort of arcade, which together with the shops is within the subway structure. At the station in South Brooklyn where the independent subway line crosses the existing Fourth Avenue line, several shops are provided within the subway structure at the street level, and the city is preparing to furnish heat to its tenants at these shops.



Operating Equipment for Escalator Installation in Eighth Avenue Subway

The wall surfaces of the old stations are covered with tile and have ornamental color bands of mosaic and mosaic name tablets spaced about 45 ft. on centers. Those of the new stations are covered with tile or enameled brick, with bands of colored tile and mosaic name tablets. In addition to the latter, interchangeable unit tiles bearing the name of the station are set in the walls about every 5 ft., at the proper height, so that they may be read easily by passengers in trains. For instance, at the 42nd Street station the figures "42" are set in the wall every 5 ft. for the entire length of the platform.

In the old stations no provision was made for advertising. Advertising boards or panels were fastened to the tile surface later without respect to decoration and with considerable damage to the tile. In the wall surfaces of the new station, panels of proper sizes to hold the standard advertising sheets have been provided in the tilework. With the exception of these panels, all wall surfaces are in one plane. For the sake of simplicity and for sanitary reasons, all surfaces are designed without dust-catching ledges or projections. Tile is carried to the ceilings, which latter are of cement and rubbed to a smooth finish.

Before the older subway stations were designed an effort was made to simplify all station finish work with a view to economy and because it was believed that simple, severe, and restrained details and wall treatment were in good taste for subway structures. In the design of the new stations this view was kept in mind. Certain changes in detail, however, have been made to meet new conditions, and in these changes an attempt has been made to refine and improve the design employed in the older stations.

Elevators and Escalators Used

At two stations, 181st Street and 190th Street, elevators have been installed. The depths of the stations below street level are 107 ft. at 181st Street and 137 ft. at 190th Street. There are two elevators at each point, with provision made for a third if needed. The capacity per machine is 11,000 lb. at 450 ft. per min. They are of the most modern gearless type, with variable-voltage control and power-operated hatchway and car doors. Power operation, by compressed air, not only shortens the stops at landings but also permits the operator in the car to control all the operations of driving machinery, car, and doors.

There is also an escalator at the 181st Street station. It is a reversible single-file machine of nearly 52 ft. rise, which is unusually high. The chain speed is 90 ft. per min. Safety buttons are located at several places for stopping the escalator quickly in case of need. On the lines included in the first step, provision for 52 escalators has been made, and it is planned to install 24 for initial operation. They are all of the single-file cleat-step type, the highest being for a 65-ft. and the lowest for a 27-ft. rise. All operate at a 30-deg. angle and are reversible. At some points part of the escalators will run up, and at others, down, and at some they will operate up during certain hours and down during others.

Safety Precautions

Everything that has been found of value to the safety of operation of the existing subways has been provided in the equipment of the new lines, and in some details the latter have increased this protection. On the old lines the local tracks were not originally equipped with block signals except at curves and other special points such as interlocking plants. In the new subways, however, all operating lines will be fully protected by means of block signals with automatic stops, and all special work protected with electric or electropneumatic interlocking.

The block signaling is designed for a capacity of 30 trains per hour. In connection with each signal an automatic stop of the trip type is used. The trip arm is in the tripping position when the signal indicates "stop," and is clear when it indicates "caution" or "proceed." The signal and automatic-stop control is of the overlap type, i.e., each signal is controlled for the braking distance beyond the next signal so that there will be two stop signals behind each train, with ample braking distance in which a following train may be brought to a stop. A train attempting to pass a stop signal will be tripped by the automatic stop and an emergency application of the brakes made which will bring the train to a stop before it reaches the preceding train.

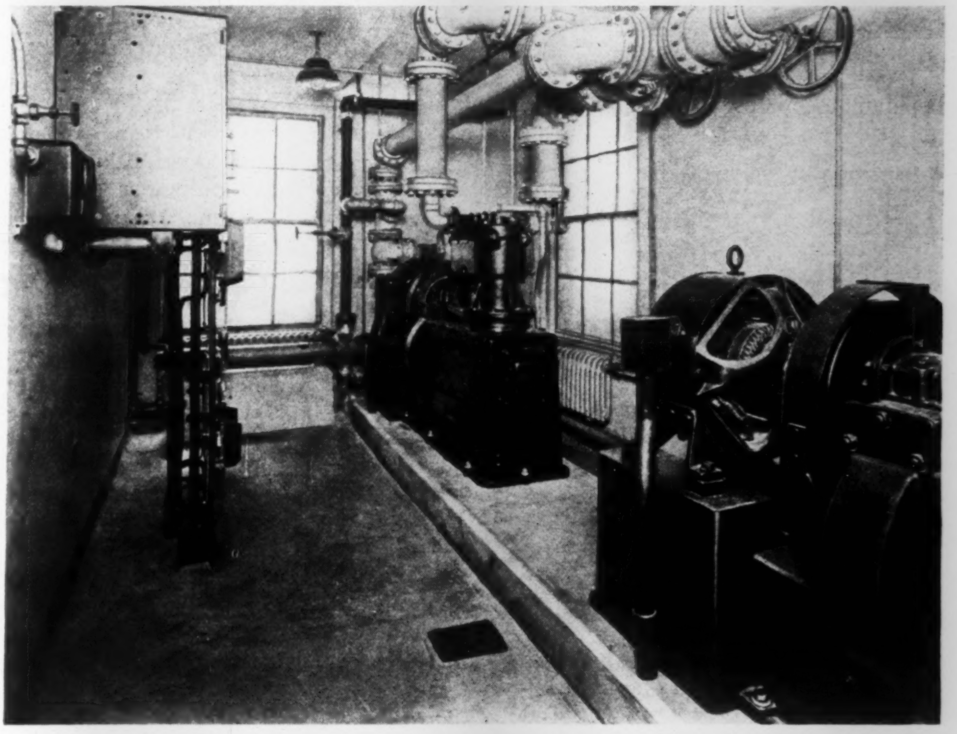
At congested locations, such as at approaches to stations, an additional control of the signals by a time-element mechanism is provided. Through this a train, by reducing its speed, and consequently the distance necessary for it to stop, will receive "proceed" signal indications and thus be permitted to approach closer with complete safety. This time-element control is also used to enforce a slow speed on long, steep, descending grades. If a train attempts to pass through an approach section at a speed greater than is allowed, it will be tripped and brought to a stop.

Natural ventilation is greater on the new lines than on the old, and emergency exits have been improved to provide easier egress for passengers in an emergency. The third rail is protected in nearly the same manner that it is on existing lines, and is sectionalized to a somewhat greater extent.

Precautions to Prevent Failure of Power

Power for all purposes is supplied by the Edison companies. Particular attention has been given to maintaining emergency power in case of failure of the regular source. Power for traction is supplied through many separate feeders from different Edison stations, which are in turn connected by tie lines so as to make a total failure of power almost impossible.

Alternating current at high voltage is delivered to the city substations, and for traction purposes is there transformed and rectified to 625 volts direct current. In the first contract for substation equipment, rotary converters were specified. In the subsequent contracts rectifiers were called for. The latter were considered for the first contract, but at that time this type of apparatus had not been developed in size sufficient for subway service and its reliability was considered uncertain.



One of the Compressed-Air-Equipment Stations

The rotaries are installed in substations of the usual type containing several units, and the rectifiers usually singly in underground chambers built close to the subway side walls. However, the substation at 170th Street is designed for the use of rectifiers, and is the only installation of this type on the Eighth Avenue line. All operations of apparatus supplying power to the line will be either automatic or under supervisory control from a load-dispatching center in the central station at 53rd Street.

Substation buildings, of which there are six used in connection with the Eighth Avenue line, are equipped and located as shown in a table at the top of the following page.

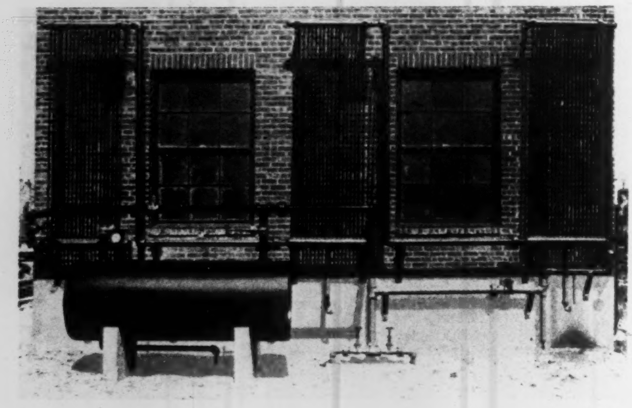
Single-unit rectifiers (each of 3000 kw.) are installed underground at 119th Street, 108th Street, 99th Street, 91st Street, 83rd Street, 72nd Street, and 63rd Street.

Tunnel and Station Lighting

Power for the tunnel and station lighting will be supplied from two separate sources from the Edison network, which is considered as the most reliable supply in existence. In case of failure of one source the lights can be connected to the other, or in case both sources fail, the lights may be supplied with current from the third rail.

Substation	Location	Present equipment	Future units
Dyckman..........	210th St. and 10th Ave....	4–3000-kw. rotaries	1
Washington Heights	170th St. near Broadway..	3–3000-kw. rectifiers	1
Harlem............	133rd St. near St. Nicholas	4–3000-kw. rotaries	1
Central............	53rd St. near 6th Ave.....	2–4000-kw. rotaries	3
Greenwich.........	13th St. and Greenwich..	3–4000-kw. rotaries	2
Cliff...............	Cliff St. near Fulton.......	3–3000-kw. rotaries	1

Power for pumps is also obtained from two independent sources, and for each elevator plant from at least two separate sources. Each elevator is also provided with an additional emergency source (storage battery) for slow-speed operation.



Cooling and Condensing Equipment for Compressed-Air Installation

Emergency stations are located along the side walls of the subway, spaced 400 to 600 ft. apart. These are provided with a telephone, fire extinguisher, and an emergency alarm box by means of which power may be cut off in a section in case of necessity. The operation of these devices will be about the same as in the existing subways, although some of the details have been modified.

Mechanical Ventilation at Certain Points

Although provision is made in the design of the subway for as much natural ventilation as possible through the use of flues, steel gratings, and liberal station stair passages, it was necessary to provide mechanical ventilation for the deeper parts. In some cases fresh air is forced in and foul air exhausted. For the initial operation of the Eighth Avenue Subway 22 fan-chamber equipments are used, and provision is made for the ultimate installation of 49. In all, 164 fan-chamber equipments are to be used in the lines comprising the first step.

The motor-driven centrifugal exhaust fans provide for a complete change of air in 15 min. They have capacities up to 195,000 cu. ft. per min. at a pressure of 2 in. of water or less. There are louvres with each fan to close the openings of the flues and cause fresh air to be drawn into the subway through the two stations adjacent to any particular fan. All the air between stations is thus renewed. The louvres are power operated, and the entire plant is remote controlled so that the louvres may be closed and a fan started, either automatically by the pulling of an emergency alarm box in a trainway or deliberately by a distant dispatcher. The plant may also be shut down by the distant dispatcher. The louvres open automatically when the fan shuts down.

Drainage Pumps—Air Compressors

Motor-driven, self-priming centrifugal pumps are installed at all low points in the subway. The standard equipment at each sump is a 100-gal.-per-min. horizontal pump driven by an alternating-current motor, and a vertical submerged centrifugal emergency pump of 500 or 1000 gal. per min. similarly driven. Both pumps are controlled automatically. While the standard sump has a capacity of 4000 to 10,000 gal., the slope of the tracks causes the total amount of water which may collect to vary greatly, hence the two sizes of emergency pumps. The Eighth Avenue Subway has 19 pump chambers, and there will be 51 pump chambers in the first step of the subway routes.

Equipment for the signal system in the Eighth Avenue Subway was furnished by two companies. That between 103rd Street and 207th Street is electropneumatic, and compressed air at approximately 70 lb. per sq. in. is carried throughout this length of the subway in 2-in. pipes. The compressed air is provided by motor-driven compressors located at various points in the section. There are two compressors of 150 cu. ft. capacity at each point, directly connected to 600-volt direct-current motors which obtain power from the contact rail. Control of the compressors is by automatic governors, and adequate cooling and condensing equipment and storage tanks are provided.

Sewage ejectors are installed at 30 station and employees' toilets which are below the level of the sewers. They have 50- or 100-gal. pots in duplicate and are operated automatically by compressed air. The air is furnished from the signal air mains above 103rd Street, and below this point, where there are no air lines, by motor-driven air compressors. The taps from the signal air main are $^1/_2$ in. or less to prevent too rapid draining of that line in case of pipe breakage. There are 12 ejector pits above 103rd Street and 18 below that point. Four 50-cu. ft. and seven 20-cu. ft. compressors are used for sewage ejection. Each large compressor and some of the smaller ones serve two pits. The compressed air for operating the louvres below 103rd Street is also furnished by 20-cu. ft. and 50-cu. ft. compressors located at the fan chambers.

The Response of Thermocouples

Effects of Temperature Gradients in the Hot Junction—Effects of Varying Temperatures on the Indications of a Thermocouple—Methods for Predicting the Performance of Any Couple of Cylindrical Form

By NEIL P. BAILEY,[1] CHAPEL HILL, N. C.

WHEN thermocouples are used in precise testing and experimental work, it is very important that the indications of the couples accurately represent the temperatures being investigated. When the entire hot junction of a thermocouple is maintained at a steady temperature, its indication is of course trustworthy provided no contaminating influences are present. However, if a heavy temperature gradient exists around the hot junction, or if the temperature is varying even slowly, the indications of the couple are questionable.

It is the object here to investigate these two sources of error, and to determine the limits within which any thermocouple gives dependable results. In Part I, the case of steady temperatures with large temperature gradients is taken up. Part II is a study of the effects of varying temperatures on the indications of a thermocouple.

I—THE EFFECTS OF TEMPERATURE GRADIENTS IN THE HOT JUNCTION

Since thermocouples are widely used in the investigation of temperature gradients in materials and the study of fluid-film temperature drops, it is desirable to know definitely how to build and install a couple to read accurately the temperature at a point. Since the hot junction of a practical couple necessarily has finite size, different temperatures will exist at the various points in this junction. The question then is: Under such conditions, what temperature will govern the response of the couple?

Experimental Study

Regardless of the method of forming the hot junction, there must always exist a surface of contact between the two metals. When the couple is made by welding, this surface may be complex, but it must exist. If this surface is thought of as a plane, three types of temperature gradients are possible: along the surface, normal to it, and across it. Any temperature variation in the hot junction can be expressed in terms of these three. To simplify the task, the effect of gradients in each of the three directions was studied individually by constructing three couples, each of which exaggerated one of these gradients.

Longitudinal Gradients. The effects of temperature gradients along the surface of contact were investigated using the couple shown in Fig. 1. This couple was first calibrated, having the entire hot junction at a uniform temperature at each calibration point, using a high-resistance galvanometer as the indicating element. Small iron-copper couples, previously calibrated with the same galvanometer, were fastened and sealed by putty at intervals along the main junction to obtain the actual temperature gradients. Different temperature gradients were established by applying heat locally to the iron element at different points. When conditions for any one gradient were established, readings for each small couple and the main couple were taken and these readings converted to degrees from the corresponding calibration curves.

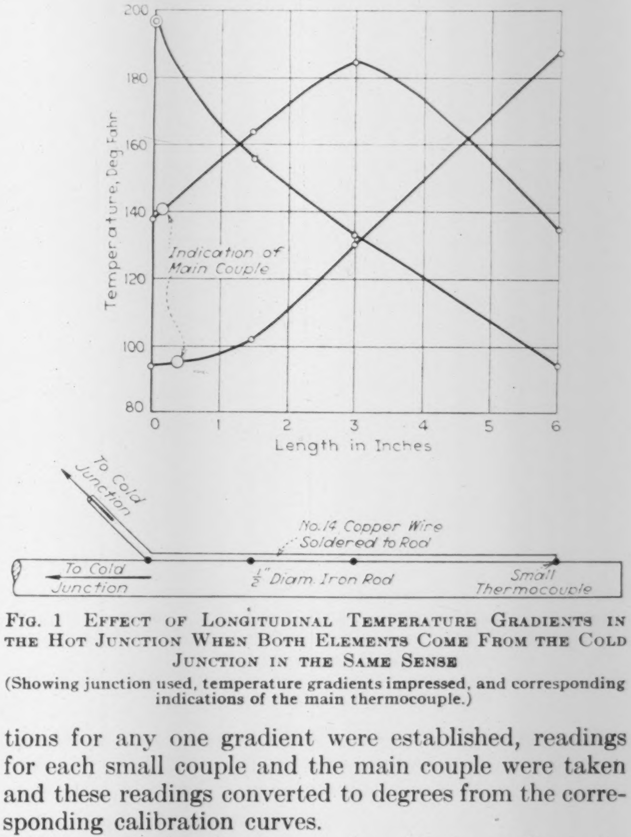


FIG. 1 EFFECT OF LONGITUDINAL TEMPERATURE GRADIENTS IN THE HOT JUNCTION WHEN BOTH ELEMENTS COME FROM THE COLD JUNCTION IN THE SAME SENSE

(Showing junction used, temperature gradients impressed, and corresponding indications of the main thermocouple.)

The results for three types of gradients are shown by the curves of Fig. 1. They show that for the case of a longitudinal gradient, when the elements come from the cold junction in the same sense, and when the cross-sections of the elements are small as compared with the length of the surface of contact, the temperature indicated by the couple is the temperature existing at the point of separation of the two elements, regardless of the temperature at any other point in the hot junction. The effect of elements of large cross-section is considered later under "Transverse Gradients."

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[1] Associate-Professor of Mechanical Engineering and Aeronautics, University of North Carolina. Assoc-Mem. A.S.M.E.

The effect of longitudinal temperature gradients in the hot junction when the two elements come from the cold junction in opposite senses was studied, using the junction shown in Fig. 2. This couple was calibrated, the small couples attached, and the test run as before. These results, shown by the curves of Fig. 2, are not as definite as in the previous case, but the following conclusions may be safely drawn: The case where the temperature at the center is greater than at the two ends shows that the temperature indicated by this couple is a function of the two end temperatures, regardless of any intermediate temperature. From the other two gradients, it may be seen that the temperature where the copper leaves the iron has more effect on the indicated temperature than does the temperature at the point where the iron leaves the copper. Thus, when a couple whose elements come from the cold junction in opposite senses has its hot junction subjected to a longitudinal temperature gradient, the temperature indicated is a function of the two end temperatures, and of the metals which make up the couple. This type of extended hot junction has had considerable use in connection with the measurement of fluid-film temperatures in pipes, upon the assumption that the indication is a logarithmic mean of the two end temperatures. Whatever type of mean it is, it seems also to be a definite function of the metals used.

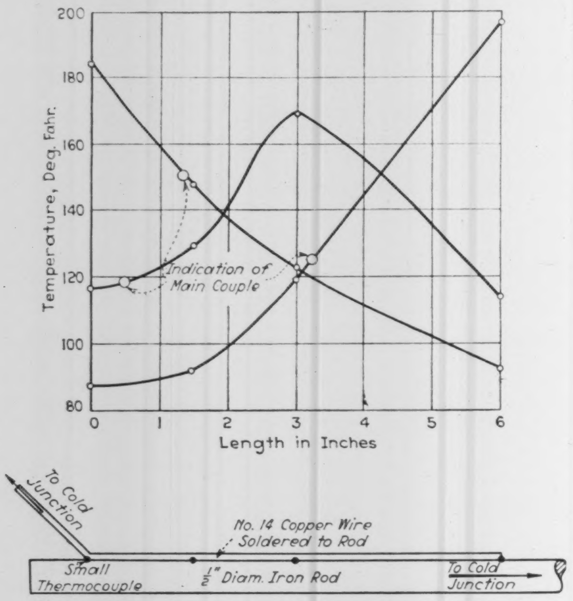

Fig. 2 Effect of Longitudinal Temperature Gradients in the Hot Junction When Elements Come From the Cold Junction in Opposite Senses

(Showing junction used, temperature gradients impressed, and corresponding indications of the main thermocouple.)

Normal Gradients. The effect of temperature gradients normal to the surface of contact was studied, using the hot junction shown in Fig. 3. Use was made of the conclusions reached in the study of longitudinal gradients; in that, after the main couple was carefully calibrated, the small couples were attached along a vertical plane through the point of separation of the two elements.

Temperature gradients were established by applying heat to the bottom of the iron element. The results given by the curve in Fig. 3 show that the temperature of the metal back from the surface of contact has no effect on the indication of the couple. The temperature at the surface of contact governs the response of a couple in case of gradients normal to the surface of contact.

Transverse Gradients. In determining the effect of temperature gradients across the surface of contact, the junctions shown in Fig. 4 were used. Couple No. I, which is shown in full lines, was tested first. The results shown indicate that for a couple of this nature, if the cross-section of metal is not reduced for a considerable distance from the surface of contact and a gradient exists along the surface, the indicated temperature will be the mean temperature of the surface.

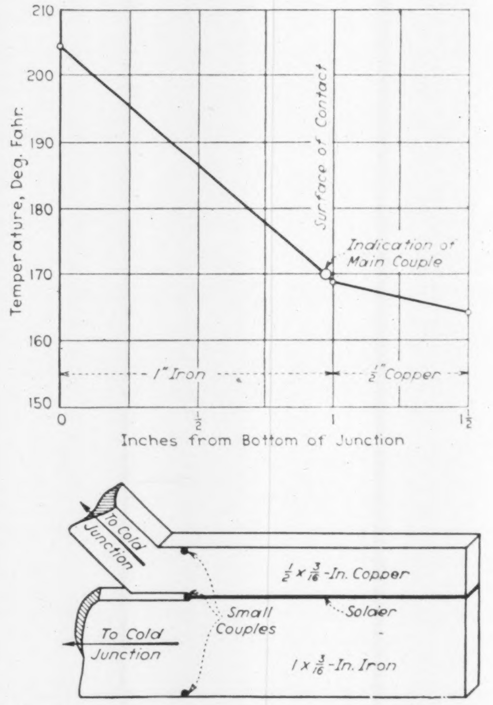

Fig. 3 Effect of Temperature Gradients Normal to Surface of Contact

(Showing hot junction used, gradient impressed, and indications of the main couple.)

Even with couple No. I where the section of the element was not reduced for a distance equal to the length of the surface of contact, the mean temperature was not recorded. The indication favors the temperature at the top of the junction where the reduced element left the junction.

To further verify this point, couple No. II was formed by cutting out the sections shown by broken lines in Fig. 4. In this case the indication favored the temperature at the bottom where the reduced element left the junction. These results show that when a gradient exists across the surface of contact, the couple will indicate the mean temperature of the surface, provided the cross-section of the elements is not reduced too near the surface of contact. It is of interest to note that the couples of Fig. 4 approach the one of Fig. 1 if the elements are reduced very near the surface of contact. Also the junction of Fig. 1 approaches those of Fig. 4 if the elements are wide.

Summary

The following conclusions may be stated from these results:

1. In any thermocouple junction, only the temperatures at the surface of contact affect the indication of the couple
2. When a long junction is formed of elements of small cross-section, the indication of the couple is the temperature at the point of separation, provided the elements come from the cold junction in the same sense
3. When an extended junction is formed by welding wide strips together along their edges, if the width of the strips is of the same order of magnitude as the length of the contact surface, the indication approaches the mean temperature of the surface
4. If two elements are butt-welded, the indication is the mean temperature of the surface of contact, provided the section of the elements is not reduced near the junction
5. When an extended junction is formed by elements coming from the cold junction in opposite senses, the indicated temperature is a function of the two end temperatures of the surface of contact and of the metals forming the junction.

II—THE EFFECTS OF VARYING TEMPERATURES

When a thermocouple is sealed to a solid body so that there is no air film around the hot junction, it is almost impossible to raise or lower the temperature of the body so rapidly that the couple will not follow the temperature accurately. However, when a couple is immersed in a fluid, the temperature of which is changing, the high film resistance around the junction will prevent it from following accurately the impressed temperature.

The cases where the time element involved affects the indication of a thermocouple may be classed under three heads:

Case I. When a thermocouple is placed in a fluid, a definite time must elapse before the indication of the thermocouple corresponds to the temperature of the fluid.

Case II. When the temperature of the fluid is changing at a certain rate, the indication of the couple will lag behind the actual temperature of the fluid.

Case III. When a couple is subjected to a cyclic temperature, the amplitude of the temperature cycle indicated by the couple will be less than the amplitude of the impressed cycle, and it will reach the corresponding points on its cycle some time later than the same points occur in the impressed cycle. The temperature wave indicated by the couple is damped in amplitude and lags in time.

The time lag involved in case I can be found definitely by test methods and offers no great problem. However, there exists no known experimental method of determining the temperature lag in cases II and III. It is desired to know how closely a thermocouple follows a rapidly changing or oscillating temperature, and yet there is no device which will follow these temperatures more closely than a thermocouple does. There exists, therefore, no standard of comparison by which to judge the performance of the couple. In the absence of a method of direct comparison, it is necessary to study cases II and III by a more indirect method.

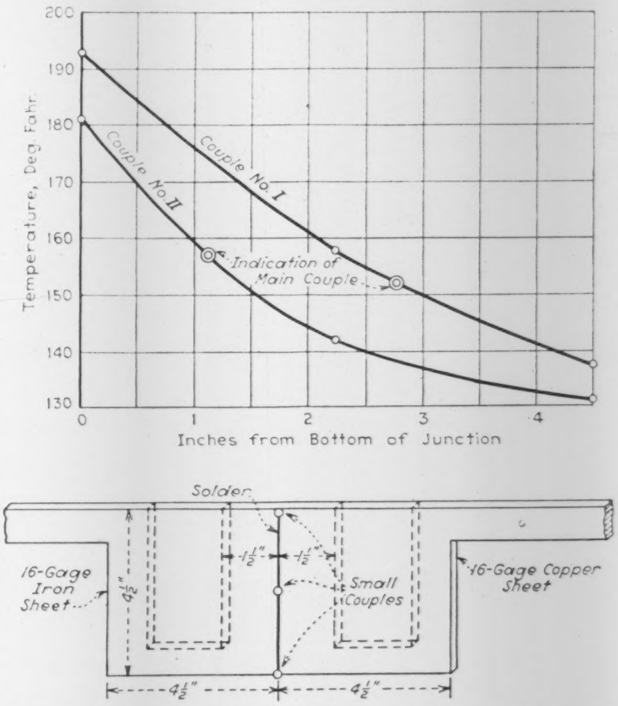

Fig. 4 Effect of Temperature Gradient Across Surface of Contact

(Showing junction used, gradients impressed, and indications of main couples. Couple No. I shown by full lines. Couple No. II same as couple No. I with portions indicated by broken lines cut out.)

Method of Investigation

Information concerning the lag of a couple behind rapidly changing temperatures was derived indirectly by making first a thorough experimental and theoretical study of case I, where a constant temperature is suddenly applied to a couple. Briefly, the procedure followed was this: Several couples were investigated under the conditions of case I, and their time-temperature curves determined experimentally. Then a theoretical method of calculating these curves was developed and found to check the tests satisfactorily. Having thus checked up the method of calculating, the performances of couples under cases II and III were calculated by the same theory.

Now as to the dependability of such a procedure. Under case I, when a temperature is suddenly impressed on a couple, the temperature change in the couple takes place under a wide variety of conditions. At the first instance, the temperature of the couple is rising under the influence of a temperature several hundred degrees hotter than the couple itself. This actuating temperature gradually decreases, until the couple approaches the impressed temperature, at which time the temperature of the couple is rising under the influence of a very small temperature difference. When a couple is subjected to a rising, falling, or cyclic temperature, at any instant the temperature of the hot junction lags far enough behind the impressed temperature to yield a temperature difference between itself and the surrounding medium of sufficient magnitude to cause its temperature to increase at a rate which, after the transient period is over, approaches the same rate as that of the surrounding medium. In all the conditions occurring under cases II and III, then, this actuating temperature difference will be well within the limits covered in case I. Viewed in this light, it is impossible to see any reason why a method of calculation which will predict accurately the performance of a couple in case I, will not give just as dependable results when used to calculate performance for cases II and III.

Theoretical Analysis of Case I. The temperature lag of a couple behind that of the surrounding fluid is caused by two things. The hot junction has finite dimensions and consequently must receive or give off a certain quantity of heat to realize a given temperature change. This heat must flow to or from it through the fluid-film resistance at its surface and through its own distributed heat resistance. In order that this heat exchange may take place, a temperature difference must exist.

For bodies the size of the hot junctions here considered, the effect of the distributed resistance of the metal has a negligible effect on the temperature of the junction as compared with the effect of the fluid-film resistance. This was verified conclusively by calculating the temperature transients in several limiting cases, first by neglecting the distributed resistance of hot junction and then considering it. The resulting partial differential equations when the distributed resistance of the junction was considered were solved by Heaviside's operational calculus in the form of an infinite series. In all cases all terms in the series after the first one were entirely negligible, and this first term approached very closely the results as obtained by the approximate method.

Neglecting then the resistance of the metal in a junction having a total heat capacity per unit length of C B.t.u. per deg. fahr. and a total film conductivity per unit length of G B.t.u. per deg. fahr. per second, the temperature of the junction at any instant plus the film-temperature drop must be equal to the applied temperature.

If T_0 is the applied temperature, measured from the initial temperature of the junction as zero, and H is the corresponding heat content of the junction in B.t.u. per inch of length, the equation stating the above condition is

$$T_0 - \frac{1}{G}\frac{dH}{dt} - \frac{H}{C} = 0 \ldots\ldots\ldots\ldots [1]$$

Solving this equation and evaluating the constant for the initial conditions, the expression for the temperature of the junction at any instant above its initial temperature is

$$T = \frac{H}{C} = T_0\left(1 - \epsilon^{-\frac{Gt}{C}}\right) \ldots\ldots\ldots\ldots [2]$$

The corresponding expression for the temperature at any time as a junction is cooled from an initial temperature T_0 by placing it in a medium of zero temperature, is

$$T = T_0\epsilon^{-\frac{Gt}{C}} \ldots\ldots\ldots\ldots [3]$$

These equations are general for any couple in any fluid, provided the appropriate values of the constants are used.

Evaluation of Constants. The values of the film conductivity were determined using Langmuir's film theory of heat convection and the data published by C. W. Rice in the 1923 Transactions of the A.I.E.E. On the basis of this theory, the total film resistance is attributed to a stagnant layer of the fluid which wets the surface of the body. This film proves to be relatively thin, and all of the temperature drop takes place in it.

It may be shown by dimensional analysis that for free convection in a fluid, this film thickness B for a cylinder is given by

$$B = DM\left(\frac{u}{pg^{1/2}D^{3/2}}\right)^m \ldots\ldots\ldots\ldots [4]$$

The fluid most commonly dealt with and the one with which the following experimental work was performed is air. Rice gives the value of m as $1/2$ and of M as 3.4 for air when u is the coefficient of viscosity, p is air density, g the acceleration of gravity, and D the cylinder diameter, all in c.g.s. units.

For small cylinders in air with a forced velocity of v cm. per sec., the corresponding equation is

$$B = 2.15D\left(\frac{u}{pDv}\right)^{1/2} \ldots\ldots\ldots\ldots [5]$$

For air, Rice recommends the following geometrical mean value:

$$\frac{u}{p} = 0.132\left(\frac{T_{\text{avg.}}}{492}\right)^{1.754} \text{ in c.g.s. units} \ldots\ldots [6]$$

where $T_{\text{avg.}}$ is the mean temperature in absolute degrees fahrenheit between the surface and the ambient air.

It was necessary to restrict all of the work to cylindrical junctions formed by butt-welding the two ends of the elements because the film-thickness data for spheres are not extended into the range here encountered, and all data available on flat surfaces apply only to large areas.

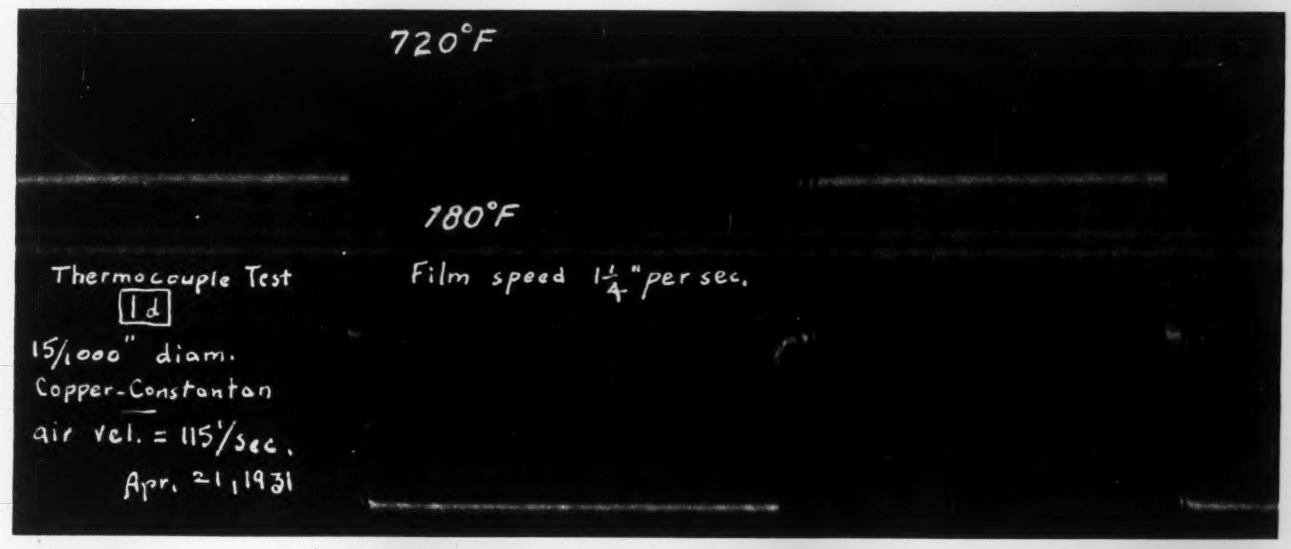

Fig. 5 Oscillogram for a $^{15}/_{1000}$-In.-Diameter Cylindrical Copper-Constantan Thermocouple for a Suddenly Applied Air Temperature

[Air velocity, 115 ft. per sec.; film speed, $1^1/_4$ in. per sec. Scale: 560 deg. fahr. per inch of height (approx.).]

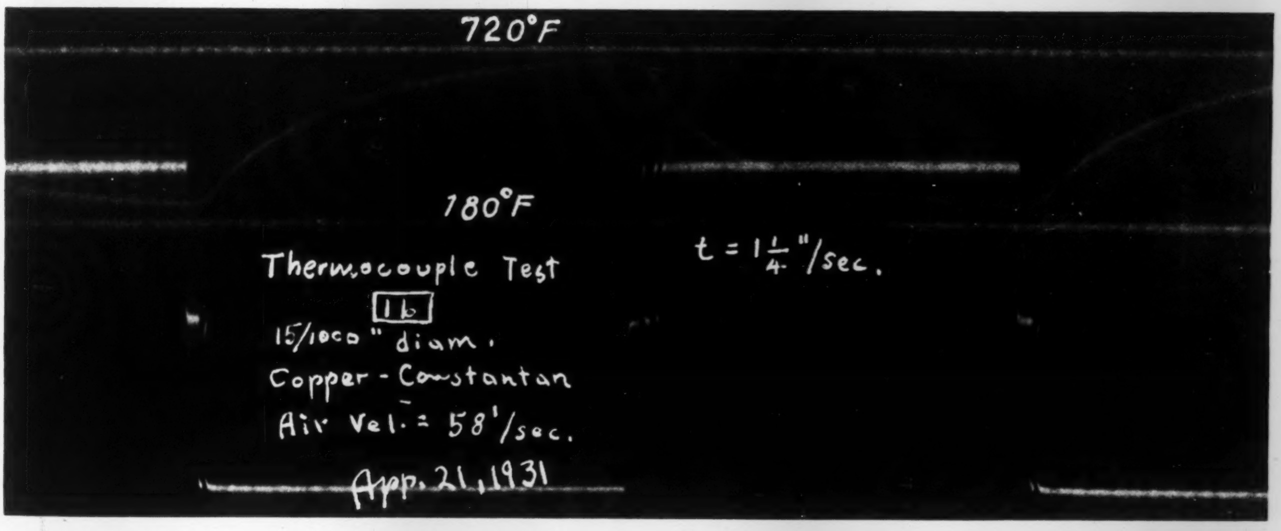

Fig. 6 Oscillogram for a $^{15}/_{1000}$-In.-Diameter Cylindrical Copper-Constantan Thermocouple for a Suddenly Applied Air Temperature

[Air velocity, 58 ft. per sec.; film speed, $1^1/_4$ in. per sec. Scale: 560 deg. fahr. per inch of height (approx.).]

Integrating for the film conductivity per inch of length in B.t.u. per deg. fahr. for a cylindrical layer of stagnant air of thickness B, gives

$$G = \frac{2\pi K}{\log_e\left(1 + \frac{2B}{D}\right)} \quad \text{[7]}$$

where K is the conductivity of air in B.t.u. per deg. fahr. per inch cube. Since K is a function of temperature, its value is given for air by

$$K = 0.282 \times 10^{-6}\,(1 + 0.00132\,T) \quad \text{[8]}$$

where T is the air temperature in degrees fahrenheit.

The heat capacity C per inch length of cylinder is given by

$$C = \pi\,\frac{D^2c}{4} \quad \text{[9]}$$

where c is the specific heat capacity of the metal of the junction in B.t.u. per cu. in. per deg. fahr., and D is the diameter in inches.

For the different metals in common use, c has the following values:

	B.t.u. per deg. per cu. in.
Platinum	0.025
Copper	0.030
Iron	0.031
Constantan	0.032
Nickel	0.034

In all calculations, the various constants were evaluated at the average of the upper and lower temperature limits involved. The approximations so involved are not serious enough to justify a longer and more rigorous method.

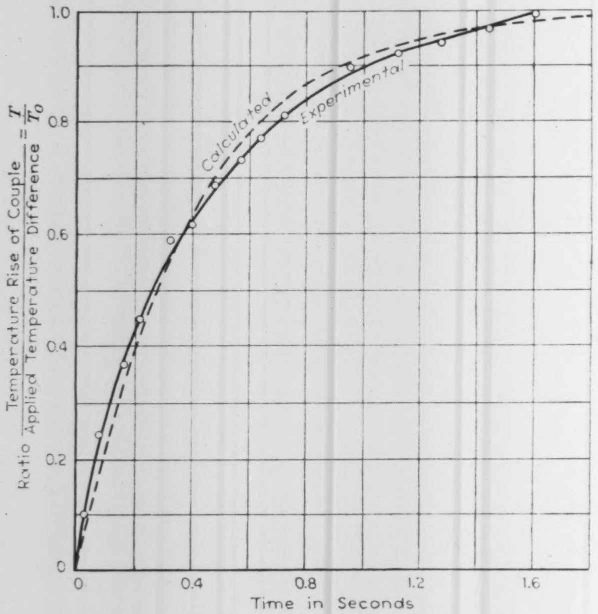

FIG. 7 RESPONSE OF A $^{15}/_{1000}$-IN.-DIAMETER CYLINDRICAL COPPER-CONSTANTAN THERMOCOUPLE TO A SUDDENLY APPLIED AIR TEMPERATURE

(Air velocity, 115 ft. per sec.; initial temperature, 255 deg. fahr.; final temperature, 720 deg. fahr.)

Experimental Work—Case I. In order to check the dependability of these equations, the following experimental runs were made for case I. Two pipes were placed side by side and air under pressure was blown through them. The air in one was heated to about 700 deg. fahr. and in the other was cold. They were arranged to discharge with their streams tangent and the velocity the same in each jet.

Various-sized copper-constantan couples were placed on a solenoid oscillator which almost instantly moved the hot junction from one air stream to the other. In this wise a temperature difference could be suddenly applied, which corresponds to the conditions of case I. The voltage output of the couple was given an amplification of 5000 by a stable direct-current amplifier, and the resulting oscillogram was taken. This amplifying circuit[2] was so designed as to give an almost straight-line calibration curve between temperature of the couple and oscillograph deflection in inches on the oscillograph. This calibration is not here included, but it had an approximate average of 560 deg. fahr. per inch height on the film.

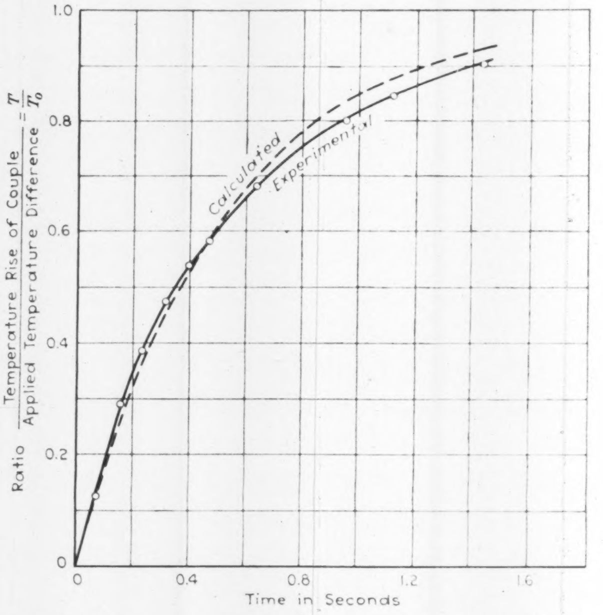

FIG. 8 RESPONSE OF A $^{15}/_{1000}$-IN.-DIAMETER CYLINDRICAL COPPER-CONSTANTAN THERMOCOUPLE TO A SUDDENLY APPLIED AIR TEMPERATURE

(Air velocity, 58 ft. per sec.; initial temperatures, 255 deg. fahr.; final temperature, 720 deg. fahr.)

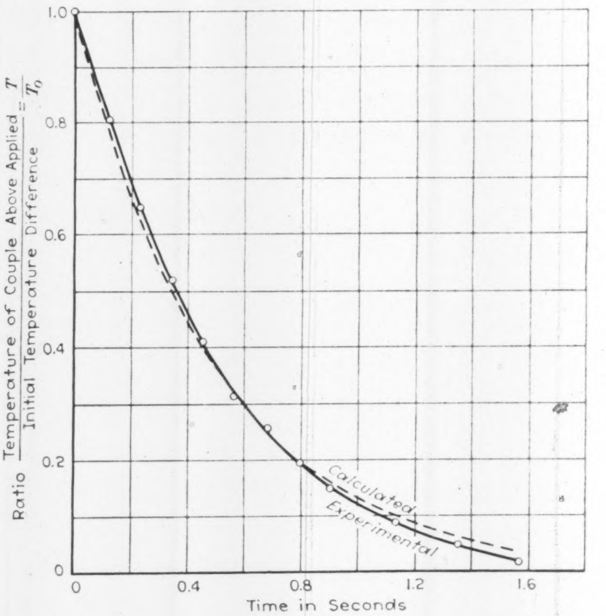

FIG. 9 RESPONSE OF A $^{10}/_{1000}$-IN.-DIAMETER CYLINDRICAL COPPER-CONSTANTAN THERMOCOUPLE TO A SUDDENLY APPLIED AIR TEMPERATURE

(Air velocity, 15 ft. per sec.; initial temperature, 800 deg. fahr.; final temperature, 160 deg. fahr.)

Curves were taken for several sizes of couples, using air velocities from 15 to 115 ft. per sec., the air velocities being determined by pitot-tube readings. The oscillograms for a $^{15}/_{1000}$-in.-diameter couple for air velocities of 115 and 58 ft. per sec. are shown in Figs. 5 and 6. Both heating and cooling curves are shown, together with the timing wave of the operating solenoid.

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[2] This circuit was developed by R. F. Stainback of the Electrical Engineering Department of the University of North Carolina, and is discussed in a thesis under his name in the Library of the University.

A number of these curves were transferred to coordinate paper and plotted with the corresponding curves as calculated from the equations previously developed. Figs. 7, 8, and 9 are typical of the check obtained. The effect of using constants evaluated at the mean temperature is apparent in Figs. 7 and 8. At low temperatures the air-film conductivity used in the equations was too high, and at high temperatures it was too low, but this error does not seriously affect the accuracy of the calculated results, and it seems safe to state that the method gives results that are dependable throughout the range of conditions covered under case I. This same method of calculating was therefore used to predict the performance of couples in cases II and III where a direct method of testing does not exist.

Calculated Performance of Thermocouples

Since the performance of a couple depends on the material of the hot junction and the film conductivity of the fluid film, it was necessary to establish a reasonable basis for the constants to be used.

A specific heat per unit volume of $c = 0.03$ was used and the film conductivity at an average temperature of 500 deg. fahr. was chosen. For average temperatures of the air above 500 deg., the performance of the couple will be better than is indicated by the curves of Figs. 10 and 11.

Solving Equation [2] for the time necessary for a thermocouple to reach 98 per cent of the suddenly applied temperature gives

$$t = \frac{C}{G} \log_\epsilon 50 = 0.092\frac{D^2}{G} \ldots\ldots [10]$$

This equation is plotted for various values of air velocity in Fig. 10. From it, the time lag involved in case I may be found.

For case II where a temperature which is rising at the rate of a degrees per second is applied to a couple, Equation [1] becomes

$$at - \frac{1}{G}\frac{dH}{dt} - \frac{H}{C} = 0 \ldots\ldots\ldots\ldots [11]$$

Solving this for the condition when the hot junction and the air start at the same temperature gives a temperature lag of the couple behind the rising air temperature of

$$\delta T = at - T = \frac{aC}{G}\left(1 - \epsilon^{-\frac{Gt}{C}}\right) \ldots\ldots [12]$$

The maximum temperature lag which is established after the transient period is over is

$$\delta T_{\text{max.}} = \frac{aC}{G} \ldots\ldots\ldots\ldots\ldots [13]$$

The time for this transient to be completed is exactly the same as that given by Fig. 10. Because of the similarity between Equations [10] and [13], Fig. 10 was adapted to show both equations. The ordinate reads directly the time necessary for the transient to be completed, and when multiplied by the rate of temperature rise a times 0.256, it gives the maximum lag in degrees of a couple behind an air temperature which is rising a degrees per second. This is the solution of case II.

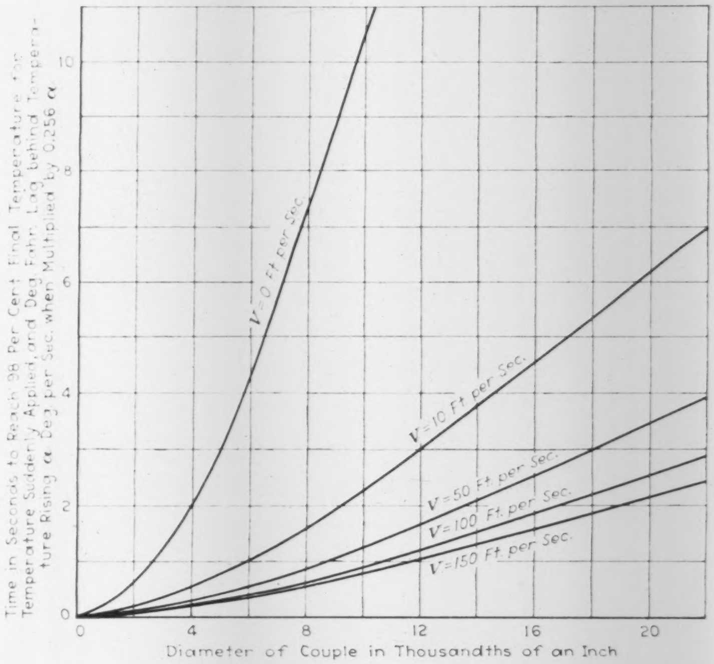

Fig. 10 Curve Giving Values of Time for a Cylindrical Couple to Reach 98 Per Cent of Final Temperature When an Air Temperature of Given Velocity Is Suddenly Applied

(The maximum lag of a couple in degrees fahrenheit back of an air temperature which is rising a deg. per sec. is given when ordinate is multiplied by 0.256a. Curves are based on an average air temperature of 500 deg. fahr.)

The fundamental temperature equation for case III when a sine wave of temperature is applied to a couple is

$$T_0 \sin wt - \frac{1}{G}\frac{dH}{dt} - \frac{H}{C} = 0 \ldots\ldots\ldots [14]$$

The solution of this equation is, neglecting the transient term,[3]

$$T = \frac{T_0 \sin\left(wt - \tan^{-1}\frac{wC}{G}\right)}{\sqrt{1 + \frac{w^2C^2}{G^2}}} \ldots\ldots\ldots [15]$$

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[3] The complete solution of Eq. [14] contains also a transient term, the magnitude of which depends upon how the sine wave is applied. It is not included here, because it is not of major interest when studying the effects of cyclic temperatures.

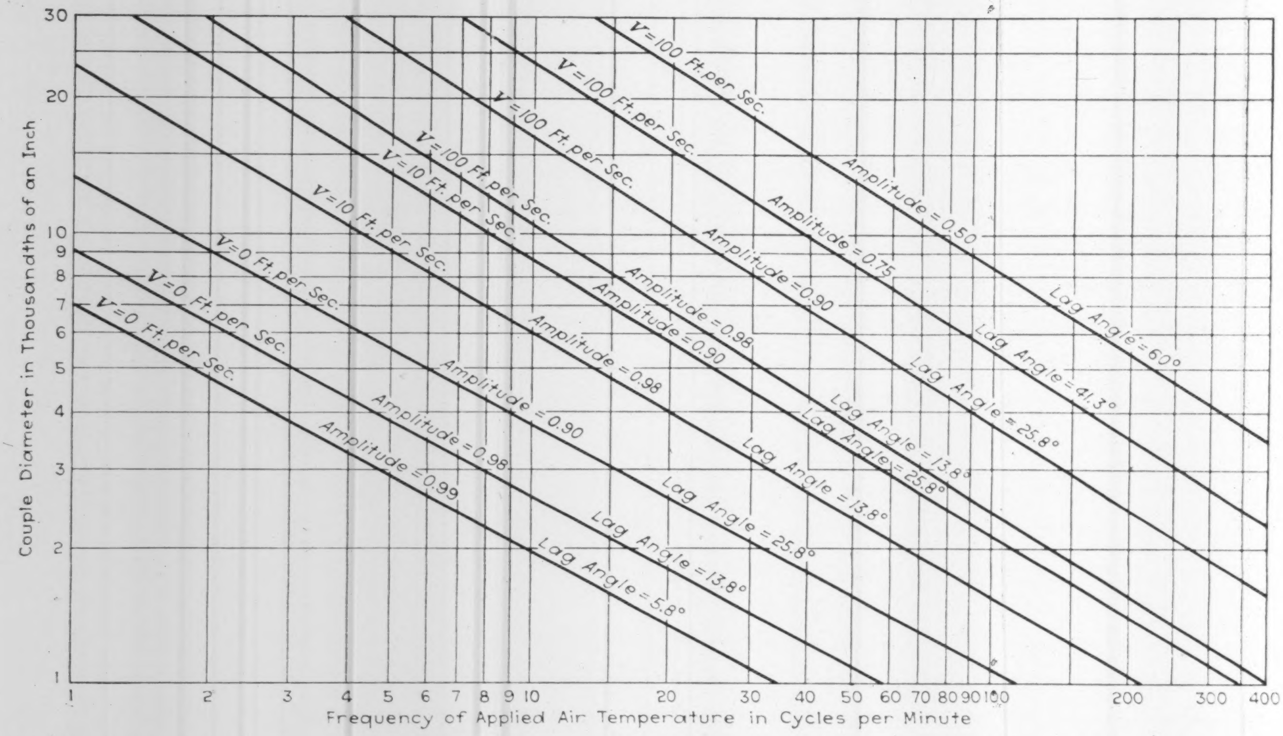

FIG. 11 PERFORMANCE OF VARIOUS-SIZED CYLINDRICAL THERMOCOUPLES WHEN SUBJECTED TO CYCLIC AIR TEMPERATURES, WITH DIFFERENT AIR VELOCITIES AND DIFFERENT FREQUENCIES
(Based on an average air temperature of 500 deg. fahr.)

This is a sine wave of amplitude

$$A = \frac{T_0}{\sqrt{1 + \dfrac{w^2C^2}{G^2}}} \qquad [16]$$

displaced an angle

$$\theta = \tan^{-1}\frac{wC}{G} \qquad [17]$$

behind the applied temperature.

Equations [16] and [17] give the performance of any thermocouple of a cylindrical form when subjected to a cyclic temperature ($T_0 \sin wt$). They are equations which involve four variables, and consequently performance curves for only a few cases may be shown in one figure. Fig. 11 gives the loci of curves of 99, 98, 90, 75, and 50 per cent amplitude and the corresponding angles of lag for air velocities of 0, 10, and 100 ft. per sec. For any frequency of temperature cycle from 1 to 400 per minute, and any couple from 1 to 30 thousandths of an inch in diameter, the performance of a couple may be found with a little interpolation for v = 0, 10, and 100 ft. per sec. These curves are of such a form as to be straight lines on logarithmic paper, and one effect of increased velocity is a slightly steeper slope.

SUMMARY

The performance of a 0.005-in.-diameter couple will be followed through to illustrate the use of these curves. From Fig. 10, if it is placed suddenly in air at zero velocity, 3 sec. must elapse before it reads 98 per cent of the applied temperature, but only $^3/_4$ sec. would be required at 100 ft. per sec. If it is placed in air whose temperature is rising at the rate a = 10 deg. per sec., in still air, after a transient period of 3 sec., it would be lagging the air temperature by 3 × 0.256 × 10 = 7.7 deg. With an air velocity of 100 ft. per sec. it would lag 1.9 deg.

This same couple will give 99 per cent amplitude and 5.8 deg. lag for a cyclic temperature of 1.8 cycles per minute and zero air velocity, or 98 per cent amplitude on 3 cycles per minute. At an air velocity of 100 ft. per sec., this same 0.005-in. couple would give 98 per cent amplitude and 13.8 deg. lag at a frequency of 31 cycles per minute.

The foregoing group of equations and curves for cases II and III cannot be checked experimentally because no test method exists. However, this same method of calculating gave dependable results when checked by tests in case I, and case I covers more extreme conditions of temperature use than either case II or case III. It is therefore felt that the methods here outlined may be used with confidence in predicting the performance of any couple of cylindrical form, and may be extended to flat and spherical-shaped hot junctions as soon as dependable data on film thickness are available for these two cases.

The author wishes to express his appreciation to Mr. R. F. Stainback for his work with the amplifying circuit and oscillograph, and to the members of the engineering staff of Leeds and Northrup Company, of Philadelphia, for their very helpful criticism.

Influence of Damping in the Elastic Mounting of Vibrating Machines

A Consideration of the Elastic Material for and the Design of Elastic Mountings Intended for the Prevention of Transmission of Vibration From Electrical Apparatus Into the Structure of a Building in Which Comparative Quiet Is Desired

By EDWIN H. HULL,[1] SCHENECTADY, N. Y.

THE present tendency toward lighter building construction creates structures which transmit noise and vibrations throughout their framework more readily than do buildings of the older types. Recently, elastic mountings have been placed under apparatus which create objectionable disturbances in these modern buildings. Excellent results are obtained in preventing the transmission of vibration to the building, provided these supports are correctly designed and applied.

Elastic supports may be divided into two types: (1) Mountings intended for isolation from disturbances of any frequency or from shocks, and (2) mountings designed for isolation from vibration of one or several known and constant frequencies. Mountings of the first type are exemplified by the automobile suspension, in which damping of some sort is known to be beneficial since road shocks may occur at the natural frequency of the vehicle on its springs. The present investigation deals with the effect of damping in the elastic material of mountings of the second type. A mounting constructed to prevent the transmission of electromagnetic noise from a three-phase induction motor to its foundation is described as an example of this second type.

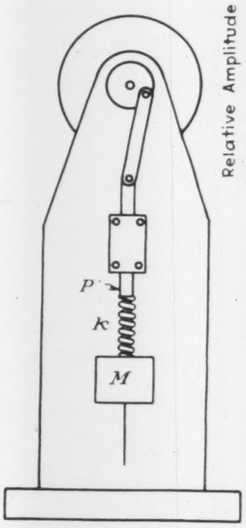

FIG. 1 APPARATUS FOR DEMONSTRATING THE EFFECT OF ELASTIC MOUNTING

DEMONSTRATION

An apparatus sketched in Fig. 1 gives an idea of the function of an elastic support. The mass M is supported through a spring k from a crosshead P moving with constant amplitude in approximately simple harmonic motion. At a very low cranking speed M moves through the same amplitude and in phase with P. As the speed increases the amplitude of M increases to a maximum at the resonant speed.

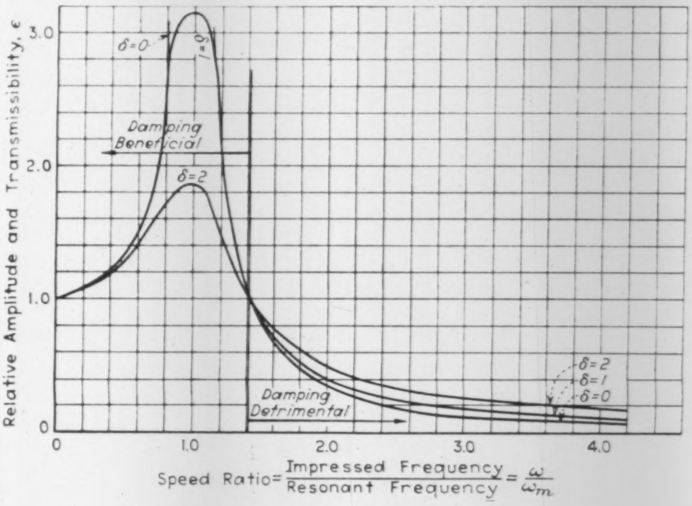

FIG. 2 AMPLITUDE AND TRANSMISSIBILITY VS. SPEED

In this range the motions of P and M, which have been in phase, shift through 180 deg. and continue out of phase at higher speeds. Any increase in speed above the resonant speed tends to decrease the amplitude of M until it is found, at a speed several times the resonant speed, that the mass remains practically stationary in space.

The curve marked $\delta = 0$ in Fig. 2 indicates the relation between speed and amplitude, showing clearly that the elastic support of M is harmful until a speed of 1.41 times the resonant speed is reached, but becomes increasingly effective as the frequency is raised above that speed. At a speed of several times that at which resonance occurs, M moves with a small fraction of the impressed amplitude.

SIMPLE THEORY

Fig. 3(a) shows schematically the essentials of the demonstration apparatus with damping added. k is the stiffness constant of the spring in force per unit deflection, the mass $M = W/g$, and the damping,

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[1] General Electric Co. Jun. A.S.M.E. Mr. Hull was born at Derby, Conn., in 1902, was graduated from the Sheffield Scientific School of Yale University in 1924, and since then has been in the Research Laboratory of the General Electric Company.

Presented at the National Applied Mechanics Meeting, Purdue University, Lafayette, Ind., June 15 and 16, 1931, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged. The complete paper will appear later in the Transactions of the A.S.M.E.

assumed to follow the viscous-friction law, contains a constant b having the dimensions force per unit linear velocity. The disturbing force of frequency ω and the resulting motions are assumed to be sinusoidal.

If the transmissibility ϵ of the system is defined as the ratio of the maximum amplitude of M to the maximum impressed amplitude, then as shown in the complete paper,

$$\epsilon = \sqrt{\frac{b^2\omega^2 + k^2}{b^2\omega^2 + (k - M\omega^2)^2}} \quad \ldots\ldots\ldots [1]$$

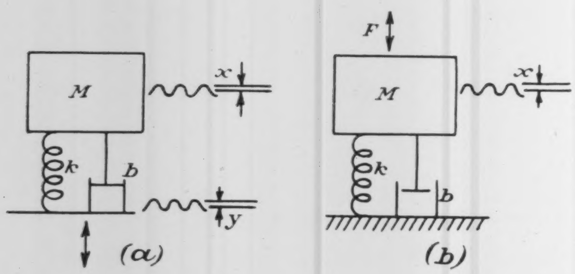

FIG. 3

When $b = 0$, neglecting the negative sign,

$$\epsilon = \frac{1}{\left(\frac{\omega}{\omega_c}\right)^2 - 1} \quad \ldots [2]$$

where $\omega_c = \sqrt{(k/M)}$, the resonant speed of the system.

Elastic mountings of the second type are usually represented by the system shown in Fig. 3(*b*). This case includes vibrating machines isolated from buildings by an elastic suspension. Here the transmissibility will be given by the ratio of the maximum value of the force transmitted to the foundation to the maximum value of the impressed force. Expressions [1] and [2] hold in this case as well as in the former.[2]

In order to obtain comparisons between various systems it is convenient to have the damping term given by a dimensionless quantity. For the cases in which the viscous-friction law holds (frictional resistance proportional to velocity), it is easily shown[3] that the logarithmic decrement $\delta = \pi b/\sqrt{(Mk)}$. Substituting in [1],

$$\epsilon = \sqrt{\frac{1 + \frac{\delta^2}{\pi^2}\left(\frac{\omega}{\omega_c}\right)^2}{\left(1 - \left(\frac{\omega}{\omega_c}\right)^2\right)^2 + \frac{\delta^2}{\pi^2}\left(\frac{\omega}{\omega_c}\right)^2}} \quad \ldots\ldots [3]$$

Fig. 2 shows that the transmissibility in the range from $\omega/\omega_c = 3$ and up may be more than doubled by common values of δ. Thus damping is beneficial in suspensions of the first type in which the speed ratio ω/ω_c may vary over an unknown range and hence be less than 1.41. On the other hand, damping is detrimental in supports of the second type, in which with proper design the speed ratio will never be near unity.

APPARATUS AND EXPERIMENTS

Since it is not known what law is followed by the friction in the various materials available for elastic support, or whether the stiffness of the material remains constant, it was thought advisable to make tests measuring the transmissibility directly. The usual troublesome frequency encountered in electrical machinery is twice the fundamental electrical frequency, or 120 cycles per second for 60-cycle power supply. By experience we have found that a speed ratio ω/ω_c of 6 or 8 is desirable in isolating this vibration. In order to make the test results as applicable as possible to practical problems, it was decided to make measurements over this range. In these measurements unit pressure and thickness of the tested materials

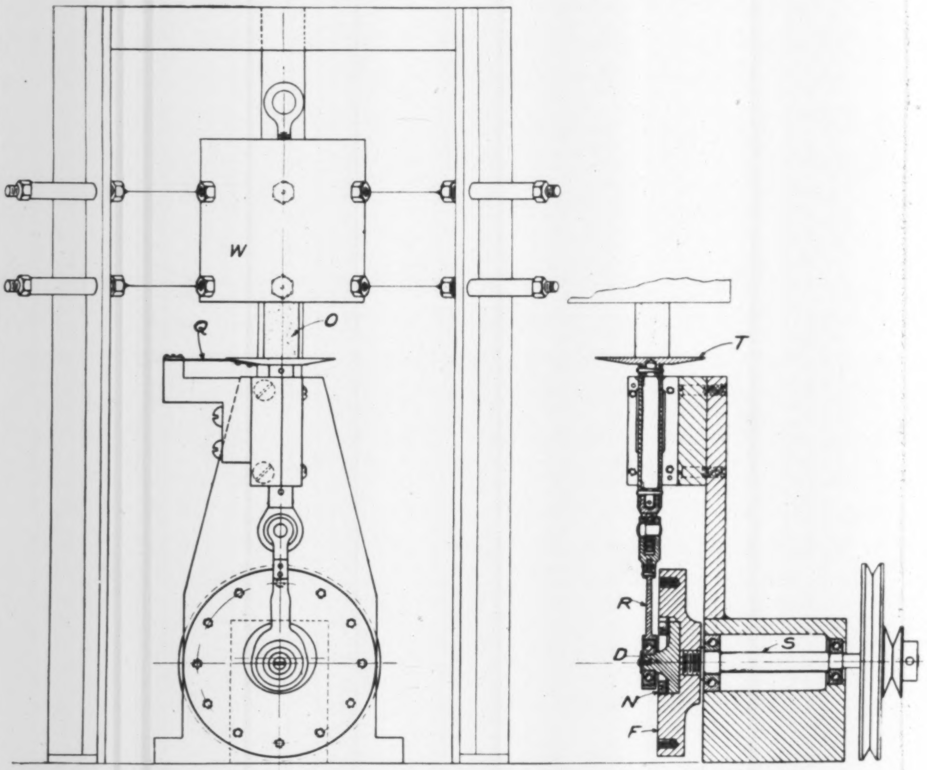

FIG. 4 TEST APPARATUS

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[2] C. R. Soderberg, *Electric Journal*, vol. 21 (1924), pp. 160–165.

[3] A. L. Kimball, Trans. A.S.M.E., 1929, APM-51-21.

were to be kept equal or near to those used in practice.

In directly determining transmissibility in a system similar to that in Fig. 3(*a*), three measurements are necessary, namely, two amplitudes and a speed. Likewise, in the system of Fig. 3(*b*) two forces and speed are necessary. Since for this case it is easier to measure small amplitudes than small alternating forces, the former system was chosen for test purposes. It is shown in the complete paper that both systems give the same expressions for transmissibility.

Fig. 4 gives some idea of the construction and arrangement of the test apparatus. The horizontal shaft *S*, motor driven through a belt and pulley at one end, carries a flywheel *F* at the other. Sunk in the face of *F* is a circular hole, eccentric with the shaft *S*. A disk *D* is held in this hole by the nut *N*. *D* carries a ball-bearing support at a distance from the disk center equal to the eccentricity of the hole in *F*. Hence, by changing the angular position of *D*, the eccentricity of its ball-bearing support may be varied from zero to twice the eccentricity of the support in *D*. A connecting rod *R* leads to a crosshead carrying a table *T*. Any slight rotation of *T* is prevented by the horizontal phosphor-bronze strip *Q*.

Samples of isolating material *O* are placed on the table *T*, and support the $48^1/_2$-lb. weight *W* which is prevented from tipping by six horizontal wires. Speed is measured by an electric tachometer having a range up to 10,000 r.p.m. Two cathetometers, supported at points some distance from the apparatus, measure the amplitudes of the table and weight, respectively, by reading the apparent width of a point against a calibrated eyepiece scale. A dial indicator (not shown) was used to read the weight amplitude near resonant speed.

In performing the tests, the eccentricity was adjusted to produce a double amplitude of the platform of 12–15 mils. The thickness of the sample was initially chosen as that recommended by the manufacturer of the material and the area adjusted to conform with his recommended loading pressure. Readjustments of these dimensions were often necessary to give proper isolation. The prepared sample was placed centrally on the platform and the weight lowered upon it.

As the speed was slowly raised, the platform and weight amplitudes and speed were read at frequent intervals. The first occurrence of interest was the maximum-amplitude point of the weight, which was carefully determined. Readings were taken at frequent intervals from this point up to the highest speed which would produce a readable amplitude of the weight, or until vibration in the microscope supports made further reading impossible. In certain cases the energy dissipation due to friction in the sample raised its temperature sufficiently to change its stiffness and friction coefficient. When this occurred the sample was run at a high speed until a temperature equilibrium was reached, the readings then being taken as the speed was decreased.

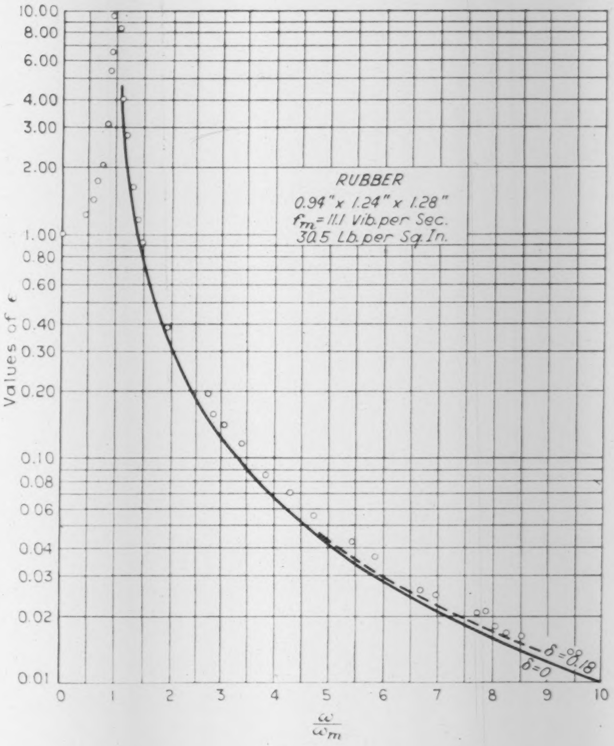

Fig. 5

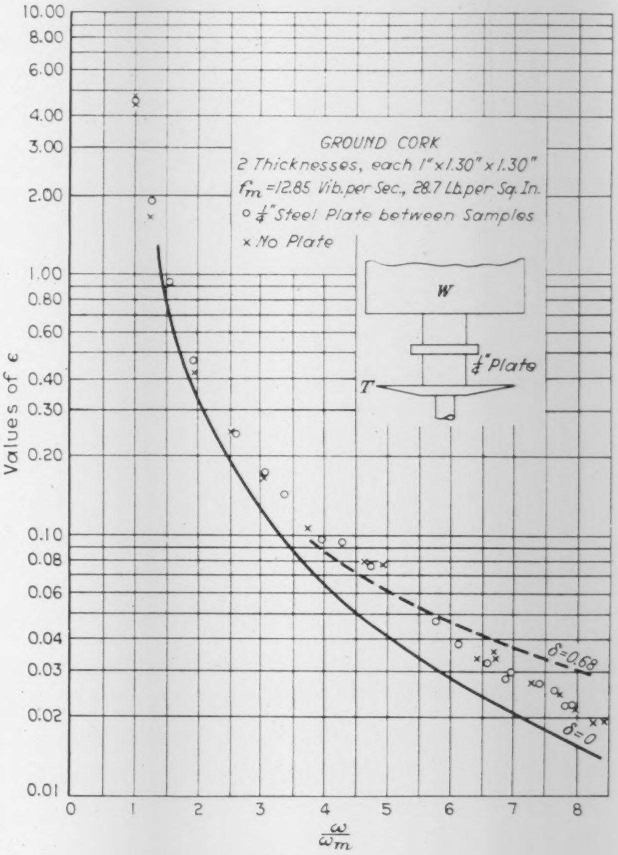

Fig. 6

RESULTS AND DISCUSSION

Results were plotted as shown in Figs. 5–7. The transmissibility ϵ is, as before, the ratio of the amplitude of the weight to the platform amplitude and is plotted on a logarithmic scale in order to magnify the situation at high ratios of impressed frequency to frequency of maximum amplitude of the weight, ω/ω_m. f_m, noted on each set of curves, is the frequency in vibrations per second corresponding with ω_m, an angular frequency. The solid line on each of the plots given in these figures is the $\delta = 0$ curve from Fig. 2 representing the transmissibility which should be obtained with constant stiffness and no damping in the material. Steel springs follow the latter curve very closely.

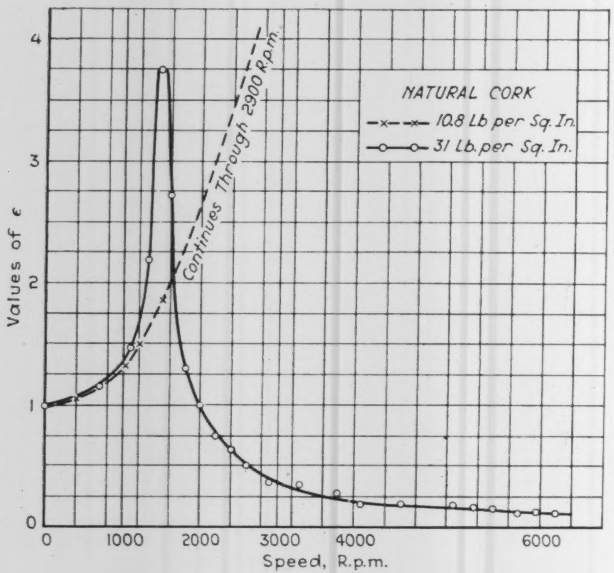

FIG. 7

Experimental results from a high-quality rubber compound, containing about 90 per cent pure rubber, are given in Fig. 5. Damping in the material is low, as is shown by the large amplitude at resonance; therefore the increase in transmissibility due to damping is small.

Fig. 6 indicates the results obtained from coarsely ground, compressed cork, and also disproves the popular fallacy that interfaces of unlike materials reflect "vibration waves" analogous to the partial reflection of light on passing between bodies of different refractive indices. Data taken with and without the steel plate between the cork samples fall along the same curve.

The broken line of Fig. 7 shows results obtained from a natural cork, intended for isolation purposes, loaded in accordance with the manufacturer's recommendations. Amplification occurs at frequencies up to 2900 r.p.m. Tripling the load per unit area gave isolation at frequencies above 2000 r.p.m. as shown by the solid curve. A figure in the complete paper shows the latter data plotted for comparison with the transmissibility which could be obtained for the same stiffness with no damping.

In the case of a special kind of hair felt made for isolation purposes, a graph given in the complete paper shows that the transmissibility is doubled at a speed ratio of 8.

A material similar to hektograph-pad gel required four thicknesses at 30 lb. per sq. in., rather than the maker's recommendations of one thickness, to produce satisfactory isolation. The increase in transmissibility due to damping was large also.

Values of δ for some of the substances tested are given in Table 1.

TABLE 1 VALUES OF δ FOR VARIOUS SUBSTANCES

Material		δ
Rubber		0.18
Special felt for supporting purposes		0.69
Cork, coarse ground and compressed		0.68
Gelatinous material similar to hektograph pad	6 mo. old	1.93
	new	1.19
Natural cork loaded perpendicular to grain		0.88

The broken-line curves in Figs. 5 and 6 show the values of transmissibility which would be obtained from these various materials based on the calculated δ at ω_m, provided these materials obeyed the viscous-friction law.

Apparently this law gives a general idea of the increased transmissibility for an average case in the frequency range of $\omega/\omega_m = 6$ to 8, but may vary somewhat for particular cases.

A comparison may be made on the basis of this theory between two mountings, one in which $\delta = 0$ and the other in which $\delta = 1$. The lower set of curves in Fig. 8 show the increase in transmissibility with increasing δ for constant speed ratios, and bring out the fact that δ has an increasingly greater effect as the speed ratio is raised. The upper group of two curves show the amount by which the stiffness of a system having a certain δ must be reduced below the stiffness of a system in which $\delta = 0$, in order that a constant transmissibility shall be maintained. When elastically mounted machines are required to transmit torque to apparatus located on a separate base, the mounting stiffness should be as high as possible, consistent with good isolation, thus requiring a low value of δ.

DRIFT TESTS

Drift tests to determine the loss in thickness with time under load were made on samples of materials used in the above experiments.

The upper curve of Fig. 9 shows the loss in thickness with time for a six-months-old sample of the gelatinous material, which had become 1.6 times as stiff as the newer sample. Even at this high loading and consequent rapid drift, the resonant frequency is too high for proper isolation.

Natural cork shows a small drift, but the resonant frequency is high. Two thicknesses should be used to reduce this frequency and obtain better isolation, in spite of the fact that the drift would be doubled in so doing.

Two thicknesses only of the special felt were tested. Even with this low loading, the drift is great and the stiffening with time fairly large. If the test had been made with four thicknesses the drift would have been twice as large and the percentage change in stiffness the same.

Rubber, at this low loading, shows practically no drift, although at higher loadings some loss in thickness would begin to appear.

Ground cork, when loaded to a value just below the manufacturer's recommended range, shows a very large initial drift. The frequency increase is considerable also.

Rubber in a Motor Support

In choosing the elastic material for mountings, several considerations point to rubber as being the most advantageous to employ. Its damping is low, much energy may be stored in a small volume, protection from oil can be arranged, stiffness in various directions may be controlled by shape, drift is small at low pressures, and finally, its life, when compounded with antioxidants, is fairly long.

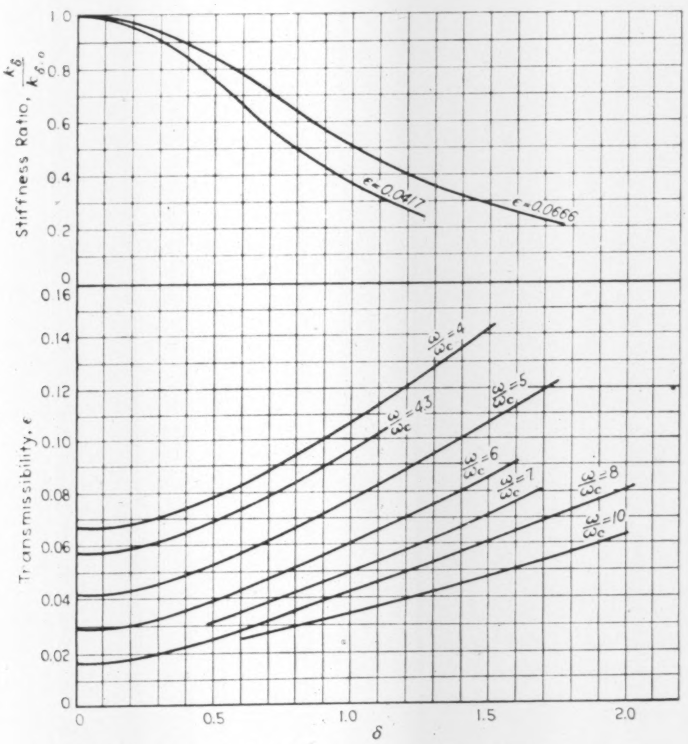

Fig. 8 Comparison of Mountings for Various Decrements

As an example of the use of rubber may be cited a three-phase induction motor driving a ventilating fan in an office building. The sliding base under the motor is isolated from the foundation by rubber placed in four symmetrically disposed metal boxes. An induction motor may have vibration components along each of its three coordinate axes, therefore the mounting must be elastic in all directions. A motor on such a mounting has six modes of vibration, and hence six natural frequencies, all of which should fall outside the running range of the motor. Since a floor is most sensitive to vibration in a vertical direction, the natural frequency of the motor on its mounting must be low in that direction. The fundamental frequency of the impressed force is 120 cycles per sec. for a 60-cycle power supply, hence the vertical natural frequency referred to above should be about 15–20 cycles per sec. The mounting mentioned isolated the motor very satisfactorily, and also appeared sufficiently stable for good belt operation.

It has not been found possible to make the mounting stiffness of motors transmitting torque to apparatus on separate bases sufficiently low to isolate from unbalance vibration unless the motor speed is high. Proper mechanical balancing will nullify this disturbance at the source. In machines which share a common base, such as motor-generator sets, the natural frequencies of the set on the mounting may be made sufficiently low to give adequate isolation from the unbalance vibration. Of course all higher frequencies are isolated even more effectively.

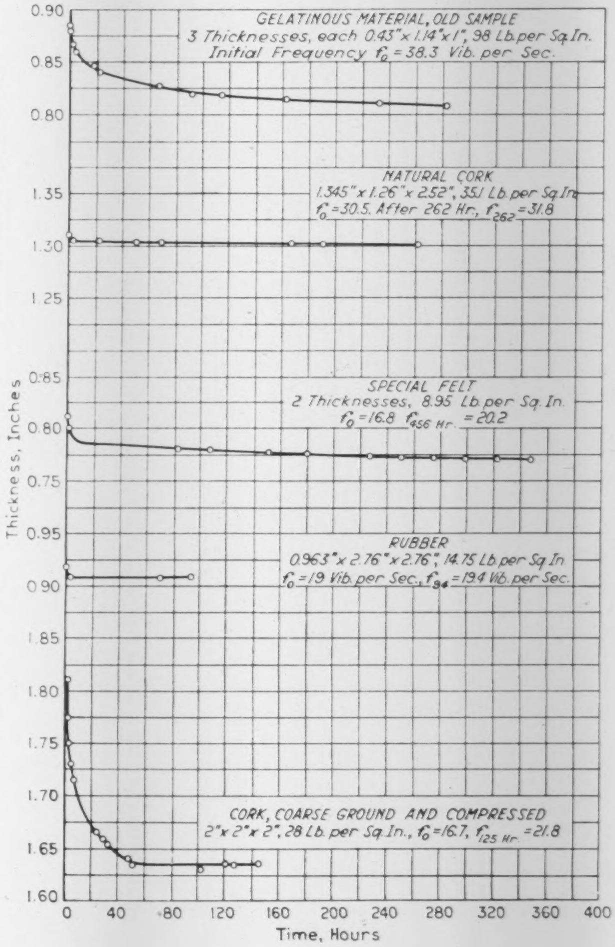

Fig. 9 Drift-Test Results

The Selection of Design Engineers[1]

THE field of mechanical engineering may be viewed as one of fairly specific design and one that generally draws into such a field many who are primarily concerned with the operation of mechanical apparatus and plants. It is the intent of this paper to present a summary of one view of the different branches of design, with comments on the qualities that seem most desirable in men who apply themselves to the different kinds of work.

The growth of industry has led to a division of the functions of design engineers that, for the purposes of this paper, will be designated: 1, Apparatus Design; 2, Plant Design; and 3, Design Analysis. These functions can be subdivided into important parts for the purpose of considering the qualifications of engineers.

Apparatus design is considered as covering the field of machine design and kinematics, heat-transfer apparatus, and machines and apparatus that have to do with the flow of fluids, both liquid and gaseous. Those engineers engaged in what has been termed "apparatus design" are considered as working in or directly supervising a drafting room where designs are made from which the manufacturing or building is done; they are the staff of draftsmen.

Plant design is considered as that branch which arranges machines or groups of machines which serve as a unit into a producing plant. It includes all the important works of shop and plant arrangement, and has the essential function of coordinating the work of apparatus designers with that of plant operators or the production staff. It also covers the field of the mechanical engineer's work in the structural design of buildings. The details of connecting apparatus frequently are part of this design work.

The term "design analysis" is applied here to the work which has become of great importance in the general administration of industries engaged in the manufacture and fabrication of engineering apparatus and also in the operation of plants where the apparatus is installed. Design analysis is considered as covering the mathematical application of the laws of thermodynamics, hydraulics, and the flow of fluids, and stress determinations and vibration effects from inertia forces and rotating parts to machines and plants. It frequently has placed on it the burden of determining whether a proposed machine or a process of manufacture or operation that is in accord with scientific laws is practical in a commercial sense. The work of design analysis is considered also, in some of its phases, as related to the functions of engineering economics. It has also grown in one form or another to be the tie between the work of the laboratory, the development floor or shop, and those engaged in apparatus and plant design.

The desirable qualities and characteristics of men engaged in the different branches of design may be generally summarized and classified for purposes of selection into a relatively few divisions.

Apparatus design yields success with great ease to the man with ingenuity. If the faculty of devising ingenious parts or motions of other features is tempered by patience and persistence, it seems that the man generally grows quickly out of the one subject or work he has been following.

Plant design, because of its requirement for coordinated effort, can be considered as placing a premium on the qualities of attractive personality and memory. The ability to summarize concisely and observe closely seems also to be reflected in successful individuals in this work.

Design analysis apparently finds its successful men in those having a reasonable command of applied mathematical laws, the quality of studious attention to references that have been published, and originality in analytical thinking.

Apparatus design demands a knowledge of applied draftsmanship. The American university graduate generally is without much training in this subject, and acquires it only by starting at the very bottom in the drafting room. It also requires mastery of the application of the formulas of mechanics, kinematics, flow of heat and flow of fluids, which is generally learned in practice and not in the classroom.

It would be of great value to apparatus design if academic training could be given in the limitations to practical success that are imposed by manufacturing processes in the steel mill, pattern shop, foundry, machine shop, and fabricating or assembly plant. If it were possible to instruct the American engineering student in these practical subjects some of his aversion to work in the drafting room might be removed and his excellent training in other phases of engineering made more available for apparatus design. It may even be said that at present the general rule in the selection of men for apparatus design is to require working experience, regardless of education, for any position but that of detail beginner. Plant design also requires, even in its detail parts, men with experience, although a thorough technical education may be regarded as offsetting the importance of experience.

Design analysis seems to offer an excellent field for technically educated men, especially those from American universities. It requires a broad type of technical knowledge as well as the ability to make specific application of formulas and the laws of nature. Work in this line is frequently done by technically educated men who after graduation have gone into the laboratory, the development shop, on the test floor, or into field and service engineering.

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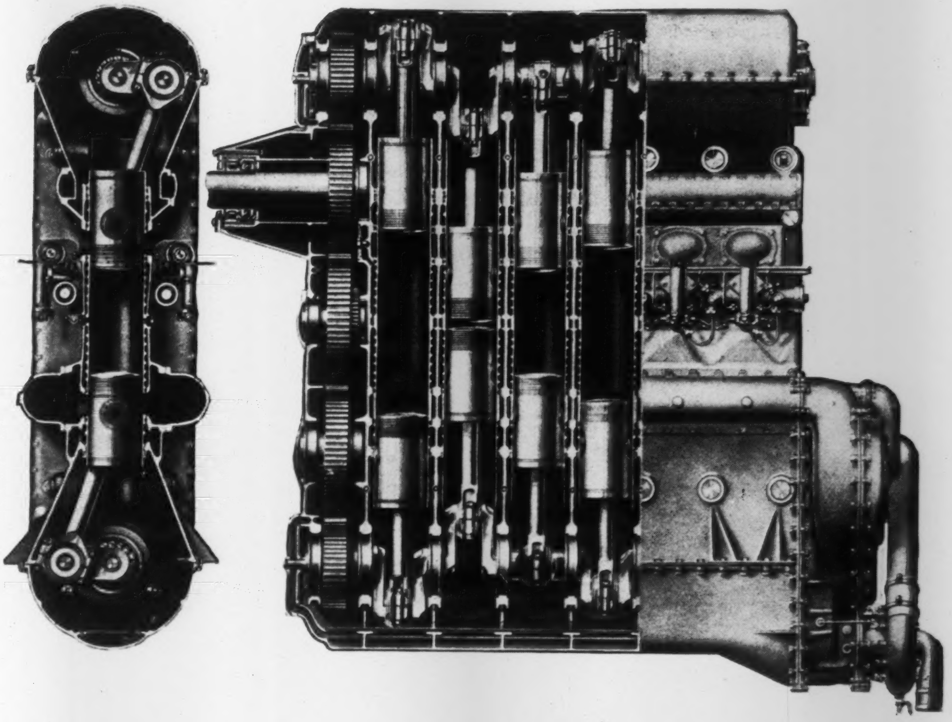
[1] Paper by Edwin H. Brown, Mem. A.S.M.E., Technical Director, A. O. Smith Corporation, Milwaukee, Wis., presented by the Machine Design Division of the A.S.M.E. at the annual meeting of the Society for the Promotion of Engineering Education, Purdue University, Lafayette, Ind., June 19, 1931. Slightly abridged.



INTERIOR OF THE "JUMO 4" HEAVY-OIL AIRCRAFT ENGINE

The Junkers "Jumo 4" Heavy-Oil Aircraft Engine[1]

THE Junkers "Jumo 4" aircraft engine is an opposed-piston, two-stroke-cycle engine operating on fuel oil and employing the Diesel combustion cycle.

Fig. 1 shows the scavenging and fuel-injection processes in the combustion chamber, and how the former can best be effected by the motion of opposed pistons. The charge of cold air enters through openings of large cross-section, flows through the cylinder without change in direction, and expels all of the hot gases of combustion through the exhaust ports. This procedure insures a clean charge, even at high engine speeds. In accordance with the method developed by Junkers in 1914 and used in all types of Junkers engines for many years, the air as it enters is set whirling spirally by the tangentially arranged scavenging ports, and maintains that motion during compression. Plunger-type pumps force a finely atomized spray of fuel into the highly heated, whirling compressed air, and a thorough mixing of fuel and air results, and in consequence complete combustion. There are no valves opening into the combustion chamber, and the inlet and exhaust ports are some distance removed therefrom. The cylinder head, which in most engines is highly stressed, is also eliminated in the opposed-piston construction.

The "Jumo 4" combines the advantage of opposed-piston operation with a better than average utilization of cylinder volume (25 hp. per liter = 0.41 hp. per cu. in., and even more) and a piston speed of 12 meters per second (2360 ft. per min.), without the aid of supercharging. The value of the two-cycle system, even for high speeds, is thus substantiated.

The scavenging air for the two-cycle system is delivered by means of a single-stage turbine blower of simple design.

CONSTRUCTIONAL FEATURES

The construction of the housing is shown in the photograph reproduced at the beginning of the paper. The pistons transfer the gas pressures through connecting rods to the cranks at top and bottom which are geared to each other and to the propeller shaft. The wristpins are of comparatively large diameter and their lubrication is facilitated by pinholes in the connections between the wristpins and connecting rods, lubricant being thus introduced with the slightest movement in the bearings.

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[1] From a paper contributed by the Junkers Research Institute, Germany, and presented by Fred. Melchoir, of the Junkers Corporation of America, New York, N. Y., at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12 to 14, 1931.

For high engine speeds, the two-cycle engine has a definite characteristic which protects the driving parts and insures smooth operation: the pressures imposed on the main and connecting-rod bearings, the crankshafts, and the gearing are more uniform and are always in one direction.

Lubrication is obtained through oil supplied to the oiling points by oil lines in the crankcase. The bearings of the connecting rods get their oil from the crankshaft through holes in the ends of the latter. The lubricating-oil and water pumps are of the usual type for aircraft, and are installed at the rear of the crankcase.

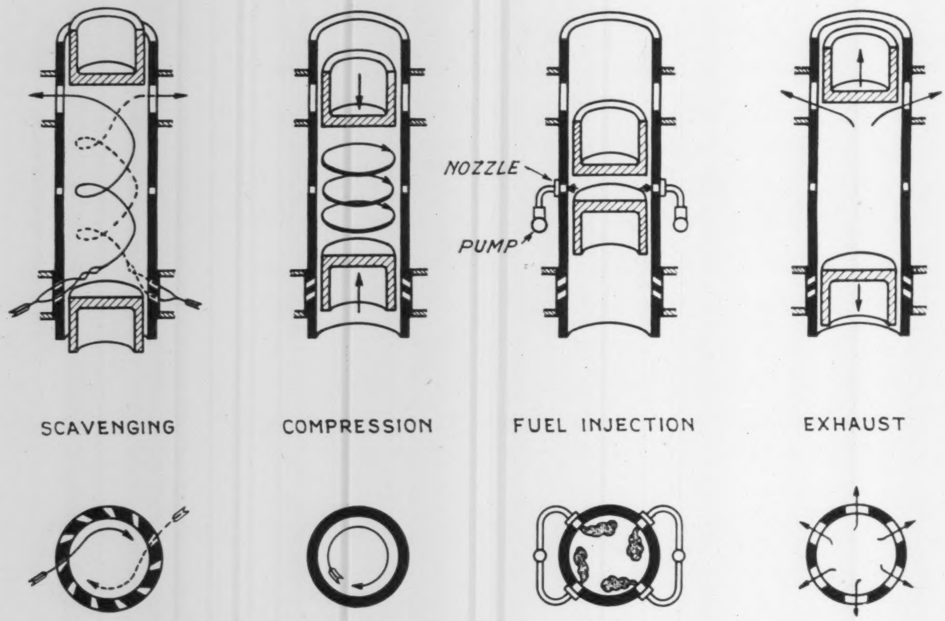


Fig. 1 Scavenging and Fuel Injection in an Opposed-Piston Engine

A new method has been employed in mounting the engine in the airplane. In this, simple, light struts run from the four panel points on the fuselage to the points of attachment on the housing block. The engine is thus mounted with the least expenditure of weight, and because of its small frontal area it causes very little wind resistance. The aerodynamic qualities of the plane are also improved by the high mounting of the propeller.

The engine is very accessible for inspection and for partial overhaul while in the aircraft. The fuel pumps are located directly at the points of injection on both sides of the cylinder, and both they and the nozzles are easily accessible. Since the crankshafts are held in place by bearing caps, the entire driving mechanism can be easily torn down and reassembled without dismantling the entire engine or even loosening any piping. The convenient accessibility of each part of the engine permits careful inspection and easy assembly. In addition, the number of parts that need replacement after a certain period of operation are materially reduced in the Junkers engine, since valves, with their complicated parts, are not used and there is no ignition system.

The elimination of valves and cylinder heads, which latter require special technique in welding and casting, the construction of the engine from similar fundamental parts, and perhaps the method of cylinder-block construction, should materially aid in adapting it for mass production.

Operating Features

In the operation of aircraft, quick starting is necessary in many cases in order to reduce the amount of time lost. The Junkers engine, even when cold, can be started immediately since it operates under high compression, and the loss of heat from the small surface area of the combustion chambers is negligible. Accessories such as hot bulbs, electric starting installations, or special fuels are therefore not necessary for starting. Low outside temperatures cause no trouble in starting since temperature, atmospheric pressures, and humidity are without influence. Ignition will not fail at high altitudes or at low temperatures since the temperature of the compressed air in the cylinders is in every instance above the ignition temperature of the fuel oil.

In flight, a single control lever for the engine is all that is necessary. Additional controls such as those required by the gasoline engine—spark control, etc.—are absent. With the one lever mentioned the amount of fuel going to the fuel pumps can be changed, thus regulating the output of the engine, whereas more or less throttling of the mixture is necessary in the case of the gasoline engine. The forced injection of the fuel charge of the "Jumo 4" gives reliable regulation throughout the entire engine speed range, as well as smooth operation from low to high speeds. It is impossible for engine troubles to arise due to dilution of the lubricating oil by unburned fuel oil, and there is little probability that the exhaust manifolds will be clogged since the fuel is completely burned in the cylinder.

The same means used on the Junkers stationary Diesel engines for throttling the exhaust may be used for high-altitude performance. The blower need only be changed for the more highly compressed air, since the single-stage turbine blower can still be built to give a good efficiency for a compression ratio of 1 to 1.8. If this ratio is not sufficient, a multi-stage blower can be built without great difficulty.

The six-cylinder in line engine construction with opposed pistons favorably influences the operating characteristics of the "Jumo 4." The free inertia forces of the opposed pistons perfectly balance one another so that no vibration of the engine is transmitted to the fuselage through the engine mount. The quiet operation of the engine is further aided by the uniform torque, which is the same as that of a twelve-cylinder gasoline engine.

In February, 1931, the type test of the Junkers engine "Jumo 4," which had already been tested under light loads in September, 1930, gave it a rating of 720 hp. (international standard) with a weight of 800 kg. (about 2.45 lb. per hp.).

The test was made on a special test stand and the output was measured by a water brake attached to the propeller shaft. For fuel, commercially available fuel oil weighing 0.86 kg. per liter (7.18 lb. per gal.), which can be bought for 0.12 mark per kilogram (9.3 cents per gallon) in Germany, was used. Ordinary aircraft lubricating oil (Voltol F) was used for lubrication.

During the test, at the request of the Deutscher Versuchsanstalt für Luftfahrt (D.V.L.), an accurate record was kept of all parts subjected to wear, since an estimate of the probable length of life of the engine forms an important item in the report of a test.

The endurance tests consisted of three full-load runs totaling five hours with an average output of 724 hp., as well as five endurance tests of ten hours each—a total of 50 hours—at nine-tenths load. The runs were made according to the requirements without difficulty. The record of the results and their uniformity may be seen in the following table.

	Hours	R.p.m.	Hp. output	Fuel consumption, grams per hp-hr.	Oil consumption grams per hp-hr.
A—FULL-LOAD RUNS IN ACCORDANCE WITH C.I.N.A. AND D.V.L. REQUIREMENTS					
1 Full-load run	1	1710	712	168	13
2 Full-load run	1	1716	725	169	14
Average		1713	719	168	14
B—SUPPLEMENTARY RUN IN ACCORDANCE WITH D.V.L. REQUIREMENTS					
3 Full-load run	3	1714	719	168	13
C—ENDURANCE RUNS IN ACCORDANCE WITH C.I.N.A. AND D.V.L. REQUIREMENTS					
First 10-hour run	10	1710	644	167	14
Second 10-hour run	10	1710	645	167	15
Third 10-hour run	10	1710	646	165	16
Fourth 10-hour run	10	1710	645	166	15
Fifth 10-hour run	10	1710	644	167	15
Average		1710	645	166	15
D—OVERLOAD RUN IN ACCORDANCE WITH D.V.L. REQUIREMENTS					
Overload run	1	1552	674	161	11

No fluctuations in the output and consumption of fuel and oil during the endurance tests, of ten hours duration each, were noticed, nor were any appreciable changes in the operation of the engine observed. The unusually low average fuel consumption of 166 grams per horsepower-hour is particularly worthy of note.

Fig. 2 presents full-load and throttled-load graphs taken before and after the endurance tests which exhibit the characteristic qualities of a Diesel engine having practically perfect combustion. The substantially horizontal fuel-consumption curve at throttled load should be especially noted. In contrast to the gasoline engine, the fuel consumption does not increase with a decrease in load; in fact, it actually decreases and reaches the remarkably low value of 158 grams per horsepower-hour at two-thirds load. Inasmuch as airplanes actually fly at cruising speed with the engine partially throttled, this characteristic of the "Jumo 4" is of particular significance.

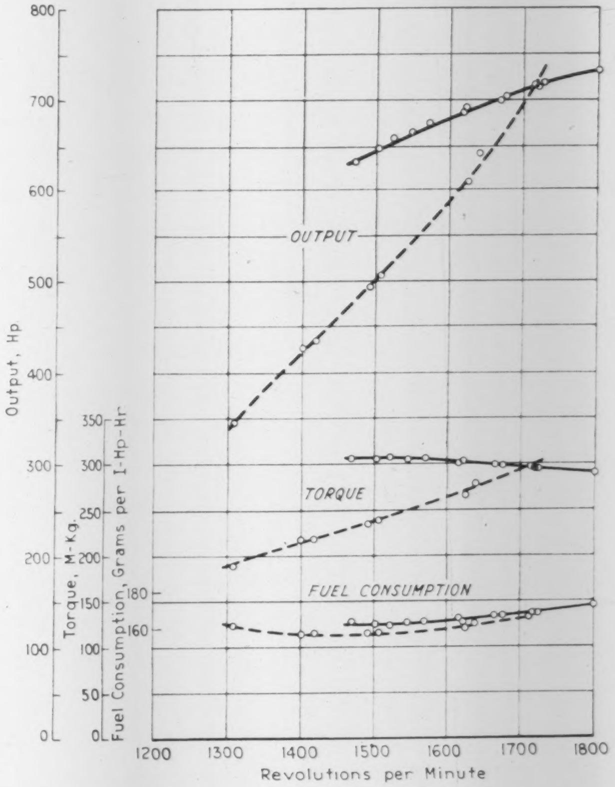


FIG. 2 FULL-LOAD AND THROTTLED-LOAD CURVES
(Solid lines, full load; broken lines, throttled.)

A one-hour overload test was also made, and in addition a one-hour test with the engine running at 1800 r.p.m. Particularly worth mentioning are the measurements of the quantity of heat in the oil and cooling water made at practically all operating speeds of the engine. In these tests less than 250 kg-cal. (992 B.t.u.) per hp-hr. were carried off by the water, while for the gasoline engine approximately 350 kg-cal. (1389 B.t.u.) per hp-hr. are carried off. This means that it is possible to cut down appreciably the radiator requirements and thereby save weight and room, as well as reduce wind resistance.

At the conclusion of the type test a study of the engine throughout its entire working range for vibrations showed that there were no critical crankshaft speeds. Further examination and measurement of all parts of the test engine, made at the request of the D.V.L., showed that no part was abnormally worn.

A HAZARDOUS MANUFACTURING PROCESS THAT HAD NOT BEEN PROPERLY SAFEGUARDED WAS RESPONSIBLE FOR THIS FIRE

(Twenty-three employees were killed; property damage was done amounting to $2,000,000; production was stopped at a time of peak demand.)

Fire Protection in Industry

Responsibility of Management for Fire Prevention and Fire Protection—Fundamentals of Fire Protection—Large Fires Seldom the Result of a Single, Simple Cause

BY ROBERT S. MOULTON,[1] BOSTON, MASS.

AN AUTOMOBILE factory in a middle-western city a few years ago erected a new plant. The best class of fire-resistive construction was used for the buildings, and a complete automatic sprinkler system was installed. The low fire-insurance rate on this fine, well protected factory group was very low, the saving in insurance premiums being sufficient to make the expenditure for fire protection a good investment. The aluminum foundry, however, a small detached unit, was not included in this program. The original wooden building served well enough for production purposes, its value was relatively small, and there was not sufficient fire insurance involved to justify the expenditure necessary for complete fire protection in the opinion of the management. Typical, shortsighted reasoning.

In due time the fire came, as fire comes sooner or later to every building where proper fire safety measures have not been taken. The wooden shell of the foundry burned, and with it were destroyed the equipment of the building, the castings in process, and all the patterns. No record was made of the damage due to loss of business to competitors while the entire factory was out of production because of the lack of aluminum castings, nor of the inevitable loss of good-will which no insurance can indemnify. Concerns which experience such losses are not proud of them. The tendency is to announce that the buildings and machinery destroyed were fully covered by insurance, and to say as little as possible about the indirect, uninsured losses which are frequently vastly more significant than the physical values directly involved. A hundred-dollar fire at a critical point can hold up production to the extent of many thousands of dollars of indirect loss.

Fire insurance is such an important element in the fire problem of industry that business executives often fail to look beyond it, and do not realize the irreparable fire losses that are not covered by insurance. The importance of the fire problem is convincingly illustrated by the attention devoted to it by the companies whose policy it is to carry their own insurance, or, in other words, to carry no insurance. Several of the large oil companies are in this class.

RESPONSIBILITY OF MANAGEMENT FOR FIRE PREVENTION AND FIRE PROTECTION

The Standard Oil Company of California has through their engineering department given intensive study to the problems of fire prevention and fire protection in their industry, and has published a comprehensive fire-protection manual. The introduction to this manual contains the following statement under the caption "Fire-Prevention Policy:"

---

[1] Technical Secretary, National Fire Protection Association. Mem. A.S.M.E.

Address delivered at an informal management conference of the Metropolitan Section of the A.S.M.E., New York, May 1, 1931.

1 All practicable measures to prevent the occurrence of fire in Company property should be taken, and consistently maintained. By "practicable" is meant all measures which are economically justified by the risks present and the property value involved. Fire-prevention measures should be considered in the same way as any other expenditure—to be made where they will save, in the probable loss and damage by fire which they will prevent in the long run, enough to return a satisfactory profit on the necessary investment.

2 In estimating the return on an investment in fire prevention, however, value should be given to such items as hazards to personnel, interruption of service and loss of business, and the adverse effect on public opinion which may result from a bad fire, as well as the actual loss of property.

3 Responsibility for fire protection lies ultimately with the management controlling the property concerned. The management may, and frequently does, designate specific parts of fire protection to subordinate executives or specialists; but such officers are accountable to the management for the proper carrying out of the duties assigned to them. Every employee, to some extent, is responsible for fire protection in so far as it is involved in his regular duties; but to function effectively along this line he must be given proper instruction and adequate equipment.

4 In the design of any new plant or part of a plant, the management should, before approving the plans, consider all the major fire causes and pass on the adequacy of the fire-preventive features of the plant.

5 Similarly, before approving any additions or alterations to a plant, the management should study the effect of the proposed changes on fire causes, and consider the resulting arrangement from the standpoint of its fire hazards.

This is an excellent statement of policy which shows clearly the responsibility of management for fire prevention and fire protection.

Progressive companies such as the one whose statement is quoted above realize that fire is not merely an internal problem, but that the fires of the communities in which they operate, of the state, and of the nation all have an effect upon business, and that reduced fire losses are good business for everybody. For this reason they support the national campaign for the reduction of the fire waste, led by the National Fire Protection Association. Organized in 1895 as a fire-insurance engineering society, the National Fire Protection Association has now grown far beyond its original scope and has become a thoroughly representative national body with a membership including influential, technical, and trade organizations too numerous to mention here. At the 1931 annual meeting in Toronto, reports from technical committees covered subjects ranging from the fire hazards of aviation to the influence of zoning upon community fire hazards. These reports, drawn by experts in their respective fields, apply to the principles of fire prevention to the specific fire problems of industry. Prepared with the cooperation of the industries affected, they point the way to reasonable safety from fire without interference with manufacturing processes or other unnecessary hardships, and are used as a basis of state, municipal, and insurance regulations and as a guide by the industries concerned.

FUNDAMENTALS OF FIRE PROTECTION

The fundamentals of fire protection are simple. Control of fire causes, elimination of combustible materials, restriction of area subject to fire, proper building construction, and fire-extinguishing equipment are all obvious methods of reducing the fire loss. Experience shows, however, that it is not safe to rely upon any one of these methods. The human element may nullify any single precaution taken, and safety depends upon adequate attention to every means of fire control.

While the fundamentals of fire protection are simple, their application often involves difficult technical problems. Consider, for example, the problem involved in the dip tank and adjoining oven used in the finishing of automobile fenders or any one of the numerous products handled through similar processes. We have here all the conditions for a severe fire: a large tank of a paint containing a flammable solvent which may have combustibility similar to that of gasoline, and immediately adjoining it an oven furnishing a potential source of ignition. The safeguarding of the individual hazard would of itself be simple were it not essential to consider the purpose of the equipment—the production of goods. The oven and the dip tank cannot be separated, for this would mean unnecessary travel of stock. A fire wall isolating this unit from the remainder of the plant would serve the purpose of limiting any fire damage, but a fire wall is out of the question with a continuous conveyor system operating. Automatic sprinklers which furnish 98 per cent protection for most hazards are of little value over a large tank of flammable liquid. A cover to drop on the tank to smother any fire which might occur would not function because stock in process would keep it from closing. This is just the problem with which the fire-protection engineer was confronted in the automobile industry a few years ago, and which he has effectively solved by a combined application of a number of very interesting devices and methods. These include automatic drains, foam fire protection, carbon dioxide fire-extinguishing equipment, inert gas systems, automatic control of explosive atmosphere in the oven, and like measures. This is a typical example of the special fire-protection measures that have been evolved for different industries, each new industrial process bringing new fire-protection problems.

LARGE FIRES SELDOM THE RESULT OF A SINGLE, SIMPLE CAUSE

Fires of serious magnitude are seldom the result of any one simple cause. The fire-protection engineer learns from experience to anticipate a combination of seemingly improbable circumstances and provides accordingly. Automobile accidents nowadays for the most part involve two or more cars. They are not simply collisions between a single car and a fixed object as in the early days of motoring. Present-day fires, or at least those which involve the largest losses, seem likewise to be the results of combinations of circumstances. Such combinations of circumstances may seem at first glance exceedingly unlikely. It is often difficult for the management to believe that there is sufficient probability of such occurrences to justify taking precautions, but the fire record all too clearly shows the inevitable result of lack of fire-protection precautions that comes sooner or later.

The Department of Fire Record of the National Fire Protection Association makes a special effort to secure comprehensive reports on all fires involving large losses, and between January 1 and May 1, 1931, recorded fifty-seven fires occurring in the United States and Canada where the losses reported were each over $250,000. An analysis of these reports brings out the fact that in most cases three of four separate factors were responsible for the loss. In the first place, there had to be an originating cause of the fire: some failure of the human element, such as careless smoking, neglect of some process involving the use of heat, or a like cause. Secondly, there was some combustible material present to ignite and spread the fire, usually an accumulation of waste or refuse of some kind which was not necessary and which should have been removed. Thirdly, there was frequently a delay in the discovery of the fire or in giving the alarm. A misguided watchman attempted to fight a fire which was beyond the capacity of the bucket of water or hand extinguisher which he had available, and valuable minutes were lost before the fire department was summoned.

The next item is the character of the building construction, its subdivision and arrangement. Large-loss fires for the most part occur in buildings of inferior construction; proper construction and arrangement from the fire viewpoint would be such that no single fire could cause very much loss, no matter what the combustibility of the contents. And lastly, some failure or inefficiency in fire-extinguishing equipment or personnel usually contributes to the large-loss fires. An automatic-sprinkler valve has been closed for repairs and not opened, reliance is placed upon an untrained volunteer fire department, adequate water supplies are lacking, or some other factor makes for ineffective fire fighting.

The majority of fires start from simple causes such as cigarettes carelessly discarded in piles of rubbish, but fire safety is no such simple matter as posting "no smoking" signs and keeping rubbish cleaned up, important though these simple precautions are. Fire protection has developed into a specialized profession, a recognized branch of engineering.

The mechanical engineer, specializing in other subjects, cannot expect in a limited time to obtain a complete mastery of fire protection, but it is a simple matter for him to apply the fundamentals to his own business with the assistance of fire-protection specialists whose advice is always available.

Progress

IT IS TRUE that much that was good has been spoilt by progress, but much that is better has been given us. Ask any one of those who revile the present age to what period of the world's history they would return, and he does not know. Ask any one of them what single thing he would give up, and he cannot tell you. There is no denying that the advances of applied science are doing some harm; they are wiping away many pleasant things and making vulgar things that were once rare. They have the defects of their merits. Men and women are not quite what they were in the past when they had to rely more upon their own labor. "Machinery," said Mr. Highfield in the address with which he opened the Faraday Centenary meeting last week, "eliminates skilled hand work, probably the most beneficial labor for man." It has, too, weakened men's self-reliance. "Men used to work with every modern labor-saving device are not likely to prove able to develop the outposts of the Empire." It, and other gifts of science, have led to domestic unrest, and the philosophy which springs from science has stolen away many of the ideals which gave strength and purpose to man.

All these defects are admitted. Yet, when we survey all the good that has been done—the removal of the causes of epidemics, the gift of light in darkness, the supply of pure water, the ease of national and international communication, the reduction of excessive labor, and the general increase of hours of leisure, with the means for their enjoyment—we must admit that on the whole, the scientist and the technologist have given the world more than they have taken from it.

If we cannot stop progress, we must make the best of it. That is literally the problem with which every advanced nation is faced. It is unthinkable that we can, or would, ever give up the blessings which we owe to applied science. The world could no longer exist without them. But we must see that they are wisely used. Let us remember that they have come upon us very suddenly, and that, in consequence, we have not been quite able to orientate ourselves to the new conditions. That is the cause of some of the complaints. In time, unless progress still outruns man's ability to control it, the world will devise means of making it tolerable. The obvious defects which accompany so much of it will disappear. Smokiness is departing, noisiness will follow it, and we may even anticipate that the "wiryness" which is the outward symbol of electric distribution will also go. Even the problem of excess production may in time be solved, and means will be found for consuming harvests which are now too great, and manufactured products which are now too numerous. These things may be left to the economists, while the engineer devotes himself to the duty which lies before him—that of removing all that is objectionable from his works and leaving only that which is good and pleasant.—From an editorial in *The Engineer* (London), October 2, 1931, page 354.

1930 Earnings of Mechanical Engineers—II

Clippings From the Chart Book of the A.S.M.E. Committee on the Economic Status of Mechanical Engineers

IN THE chart book of the survey of the 1930 economic status of mechanical engineers are plotted full details of the relationship of geographic location, of type of education, of type of industry, and of type of work to engineering earnings. We believe that engineers would rather have access to these charts from which they can draw their own conclusions than any further written statement of the Committee's findings aside from the article published in the September issue of MECHANICAL ENGINEERING, on pages 651–656. Accordingly, we plan to publish the most interesting of these charts in this and the next issue.

Median earnings—the earnings of the engineer in the middle position in the salary scale—have been used in place of mathematical averages. All U. S. figures are exclusive of teachers and Federal employees. Distribution figures, as well as salary figures, have been based upon the replies of members to the questionnaire. Only such explanatory comments as are necessary to make the significant features of these charts clear will be offered, and the curves will be left in unrefined form so as to put the original data, without "smoothing" or other manipulation, directly into the hands of readers.

CONRAD N. LAUER, *Chairman*,
Committee on the Economic Status of Mechanical Engineers.

I Age Distribution and Earnings of Mechanical Engineers in 1930: United States as a Whole

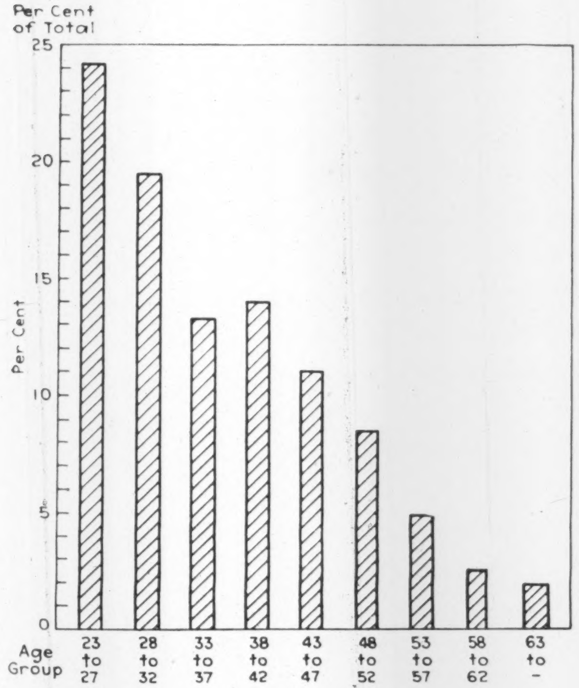


FIG. 1 DISTRIBUTION OF A.S.M.E. MEMBERS BY AGES

How much this distribution is distorted by being based exclusively on numbers of members replying to the questionnaire, is impossible to determine.

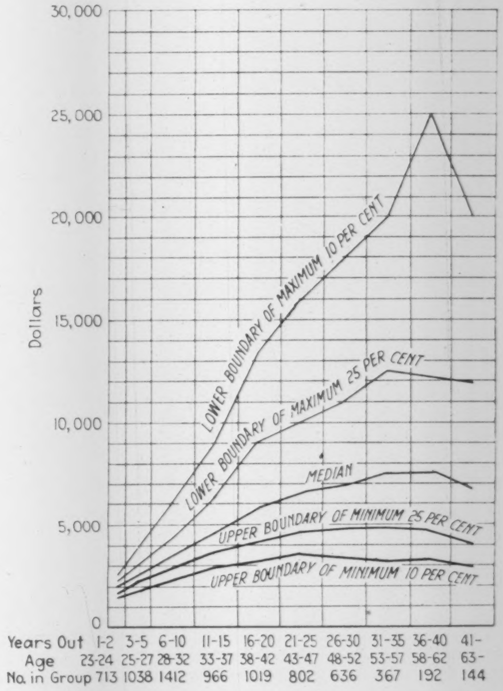


FIG. 2 1930 EARNINGS OF MECHANICAL ENGINEERS

Discussed fully in article in the September issue of MECHANICAL ENGINEERING on p. 652.

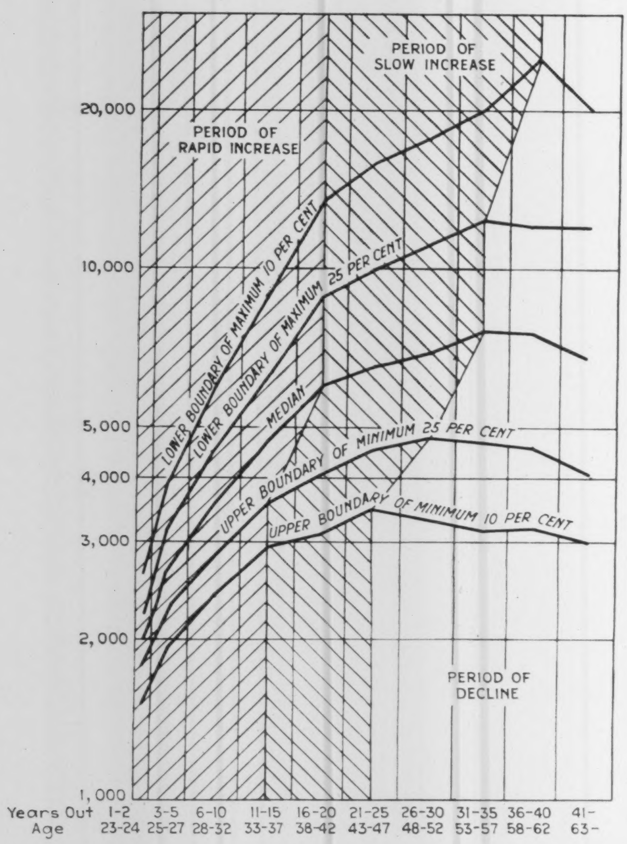


FIG. 3 1930 EARNINGS OF MECHANICAL ENGINEERS ON LOGARITHMIC SCALE

The relative gradients of the salary boundaries, because of the logarithmic scale, indicate the relative rates of salary increases per annum. This chart thus shows graphically the periods of rapid increase, of slow increase, and of decline, shown numerically in Table 1, on p. 651, of the article in the September issue of MECHANICAL ENGINEERING.

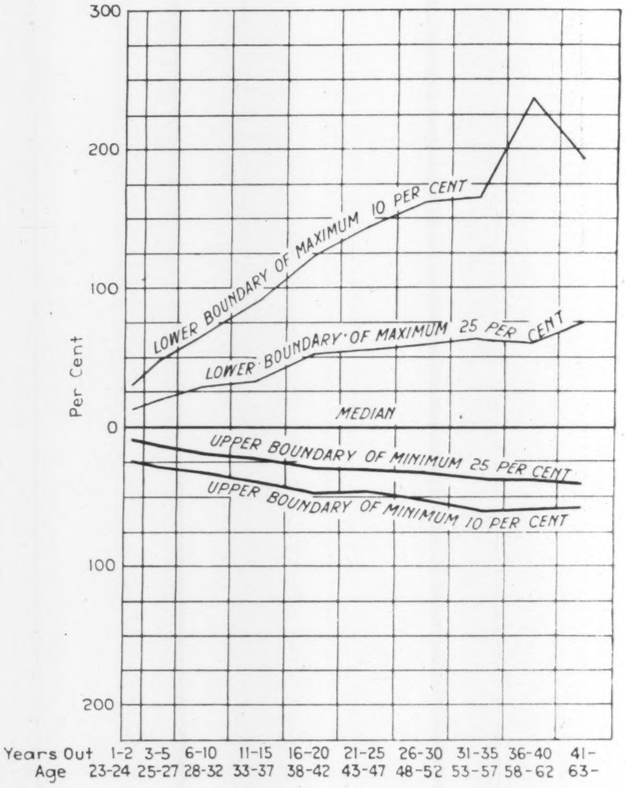


FIG. 4 PERCENTAGE OF DEVIATION OF HIGHER AND LOWER SALARY BOUNDARIES FROM MEDIAN

Note how, except at the lower boundary of the *maximum 10 per cent*, there is little change in *relative* salary between men at the different salary levels after they reach the age of 40. For example, the boundary of the lowest 10 per cent is 49 per cent below the median at 40 years of age, and 56 per cent below after 63 years of age, a decline in relative earnings of only 7 per cent in 23 years.

II Geographical Distribution and Earnings in 1930

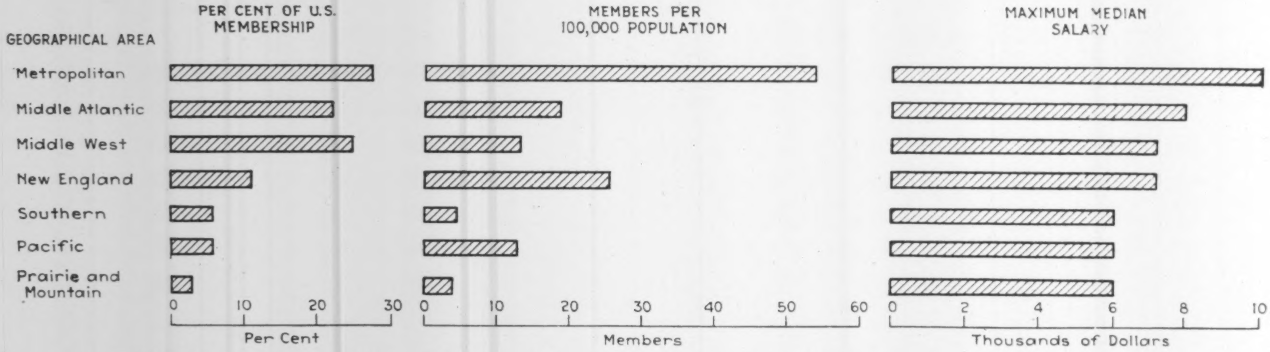


FIG. 5 RELATIVE GEOGRAPHICAL DISTRIBUTION, CONCENTRATION, AND EARNINGS OF A.S.M.E. MEMBERSHIP

The maximum salaries of the men at the median give a fair approximation of relative salary levels in the different areas. It is interesting to compare salary and concentration of mechanical engineers in the several areas. In this one chart it is possible to give distribution ratios based on figures for the total membership of the A.S.M.E. For numerical distribution, see Table 3 of the article in the September issue of MECHANICAL ENGINEERING.

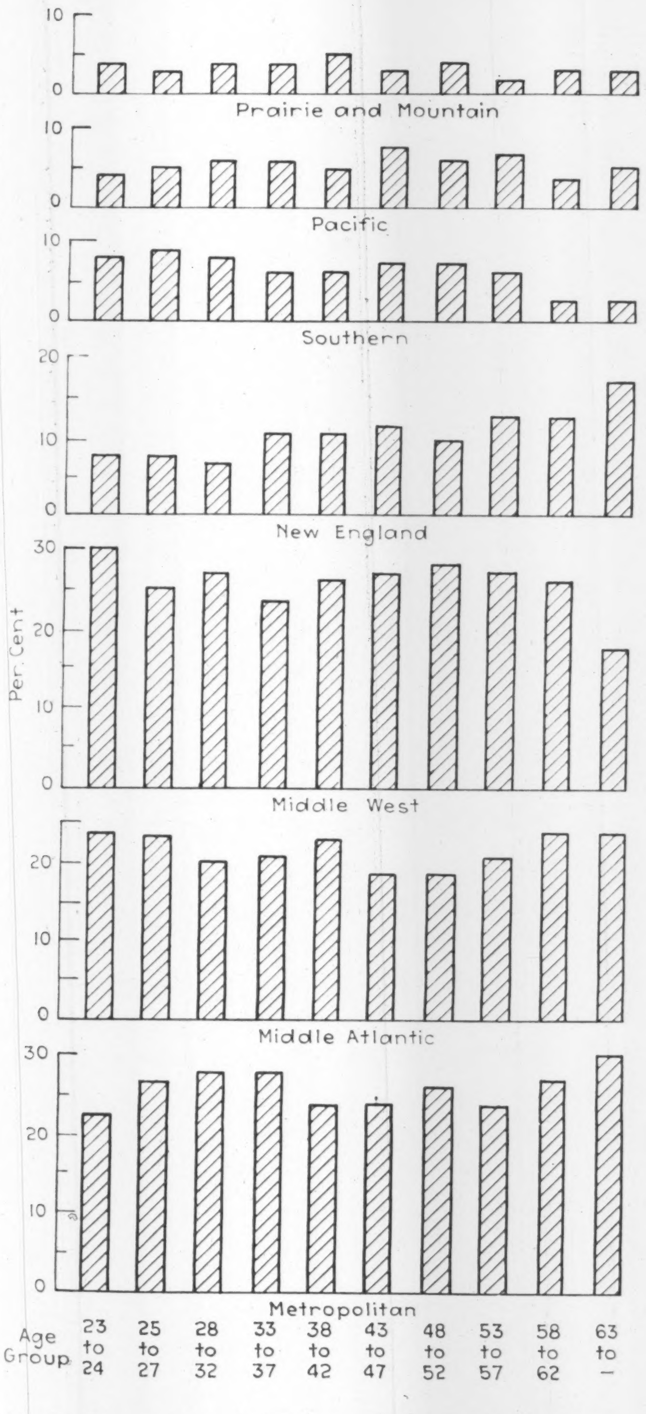


FIG. 6 GEOGRAPHICAL DISTRIBUTION OF MECHANICAL ENGINEERS BY AGE GROUPS

A comparison of these charts with those showing salary boundaries (Figs. 8–14 infra) indicates that ordinarily there is little relationship between relative geographical distribution at different ages and relative salary levels at those ages. Although New England, for example, has a much larger proportion of engineers in the older than the younger ages, New England median salaries in the last three age groups average a greater percentage below the United States median than in the first three. The high proportion of very young men and the low proportion of the oldest men in the Middle West and the reverse situation in Metropolitan New York, are interesting. So also is the gradual decline with increasing age in proportionate numbers of engineers in the South contrasted with the steady increase with increasing age in proportionate numbers in New England.

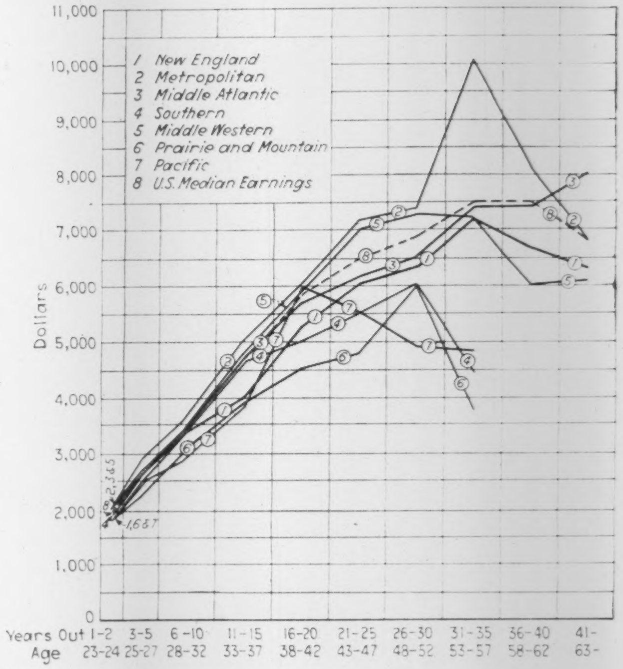


FIG. 7 1930 MEDIAN EARNINGS OF MECHANICAL ENGINEERS BY GEOGRAPHICAL AREAS

This chart was fully discussed in the article in the September issue of MECHANICAL ENGINEERING on p. 652. In considering the wide differences in earnings in different geographical areas by men over 40 years old, it must be remembered that these are the earnings of men now over 40. When the men now younger reach this age, an entirely different situation may exist.

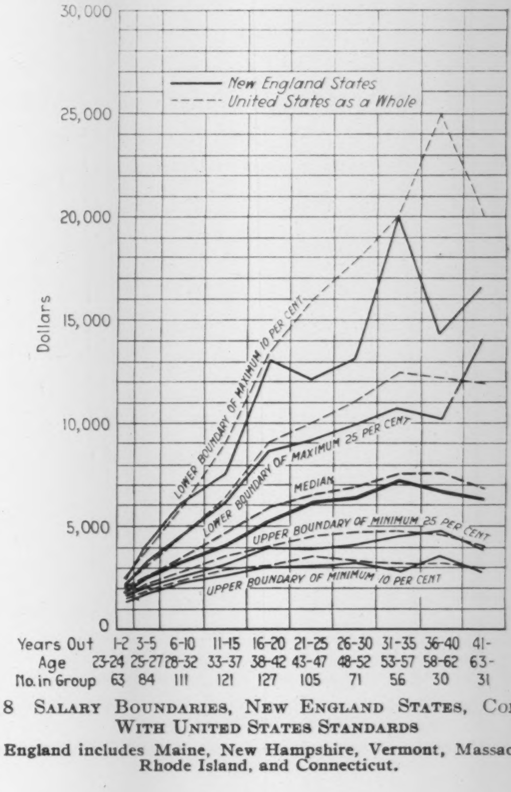


FIG. 8 SALARY BOUNDARIES, NEW ENGLAND STATES, COMPARED WITH UNITED STATES STANDARDS

New England includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

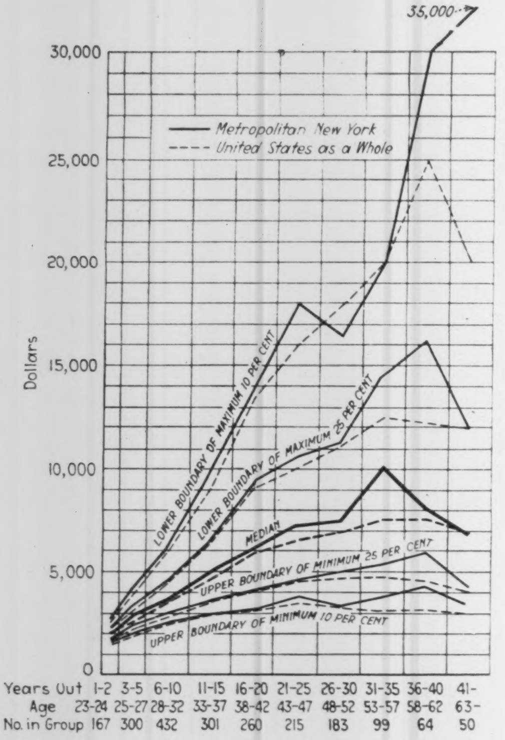


FIG. 9 SALARY BOUNDARIES, METROPOLITAN NEW YORK, COMPARED WITH UNITED STATES STANDARDS

Note how in this area the curious minor slump at the age of 50 is followed by a striking rise, compared to United States standards, at all salary boundaries. Note also how relatively small is the deviation from United States standards below the age of 50.

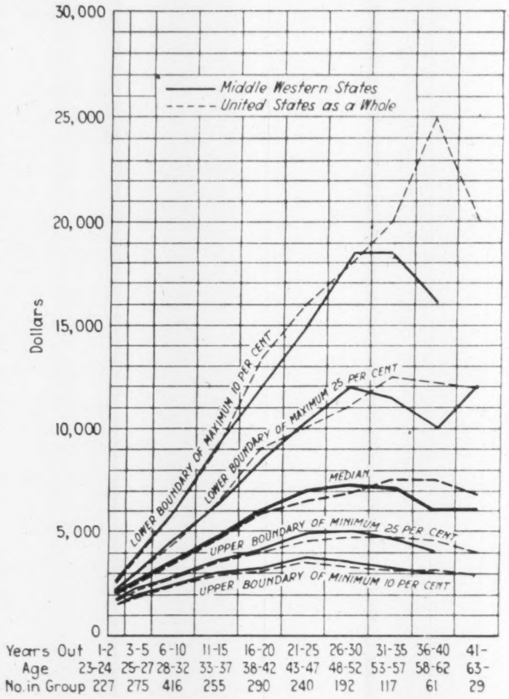


FIG. 10 SALARY BOUNDARIES, MIDDLE WESTERN STATES, COMPARED WITH UNITED STATES STANDARDS

The Middle Western States include Ohio, West Virginia, Kentucky, Indiana, Illinois, Michigan, Wisconsin, Minnesota, and Missouri. Note how in this area, men below 50 years of age are paid almost exactly United States standards at all salary boundaries, but after 50 receive considerably less than United States levels.

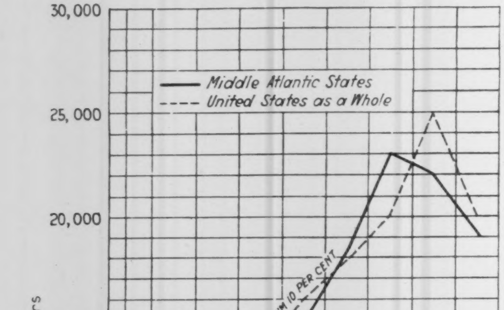


FIG. 11 SALARY BOUNDARIES, MIDDLE ATLANTIC STATES, COMPARED WITH UNITED STATES STANDARDS

The Middle Atlantic States include New York (other than Metropolitan New York), New Jersey, Delaware, Maryland, and Pennsylvania. No other area is so consistently typical of the United States as a whole.

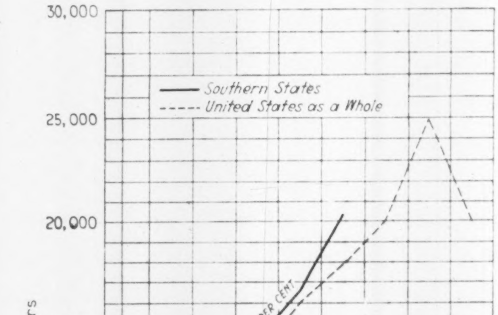


FIG. 12 SALARY BOUNDARIES, SOUTHERN STATES, COMPARED WITH UNITED STATES STANDARDS

The Southern States include Virginia, North and South Carolina, Georgia Florida, Tennessee, Alabama, Mississippi, Louisiana, Texas, and Arkansas.

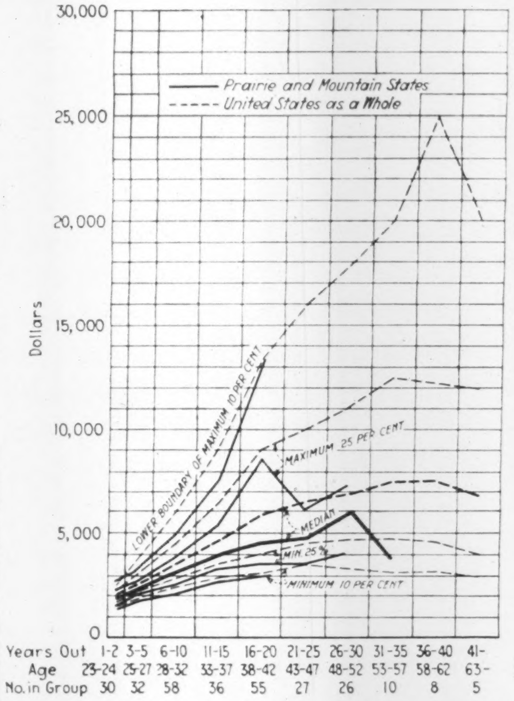


FIG. 13 SALARY BOUNDARIES, PRAIRIE AND MOUNTAIN STATES, COMPARED WITH UNITED STATES STANDARDS

The Prairie and Mountain States include North and South Dakota, Montana, Iowa, Nebraska, Kansas, Idaho, Wyoming, Colorado, Utah, New Mexico, Oklahoma, Arizona, and Nevada.

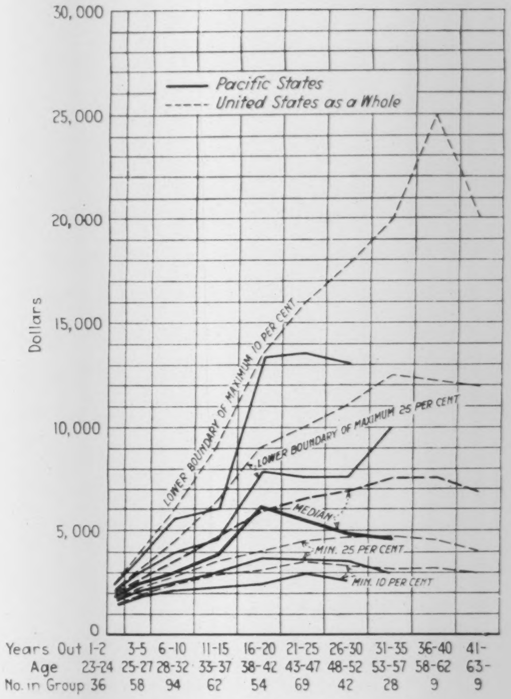


FIG. 14 SALARY BOUNDARIES, PACIFIC STATES, COMPARED WITH UNITED STATES STANDARDS

The Pacific States include Washington, Oregon, and California. The number of engineers in these and the Prairie and Mountain States is so small as to cast some doubt on the figures.

III Type of Education and Earnings

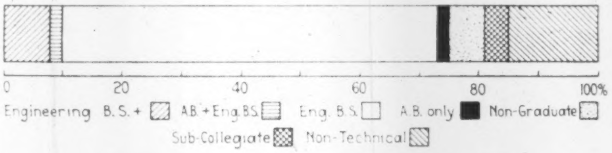


FIG. 15 DISTRIBUTION OF MEMBERS BY TYPE OF EDUCATION

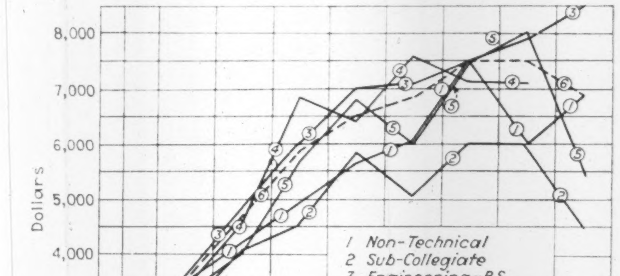


FIG. 17 COMPARATIVE 1930 MEDIAN EARNINGS OF MECHANICAL ENGINEERS BY TYPE OF EDUCATION

This chart was fully discussed in the September issue of MECHANICAL ENGINEERING, p. 653.

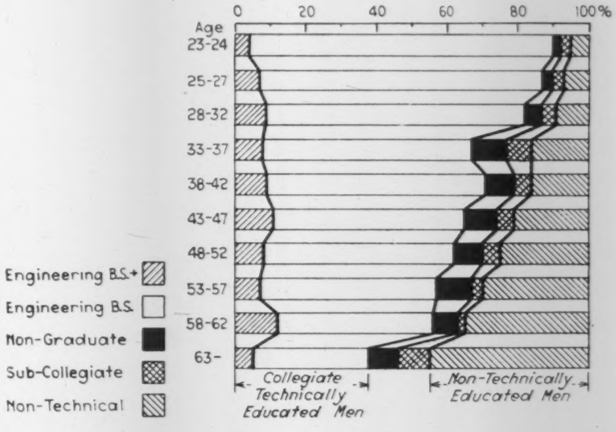


FIG. 16 EDUCATIONAL DISTRIBUTION OF MEMBERS BY AGE GROUPS

Note how greatly the proportion of mechanical engineers who have had technical education of college grade has increased in recent years. Although men without technical education would be unlikely to have worked into positions which would cause them to take out membership in The American Society of Mechanical Engineers until they have been at work for some years, by the age of 35 most men who are going to become mechanical engineers will have done so. Accordingly a comparison of the proportion of men with technical education to those without it at 35 and at later ages should give a rough, reliable indication of the striking extent to which the profession is increasingly recruiting its members from technically trained men. This fact, when considered in the light of the figures of earnings in the different types of position, raises the question of whether the relative increase in the proportion of technically trained men in the profession has not made the mere possession of that training, unsupported by qualities of intellect or personality, of much less advantage than formerly. For numerical distribution of members replying see September MECHANICAL ENGINEERING, p. 653, Table 4.

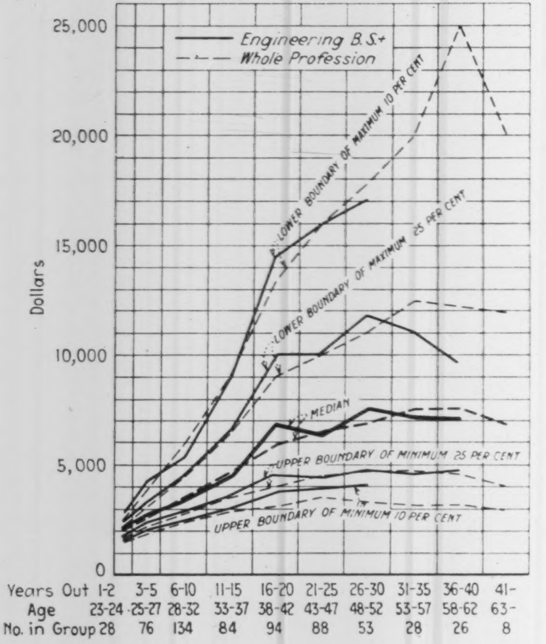


Fig. 18 Salary Boundaries of Engineers With Collegiate Plus Graduate Technical Education

(compared with general professional standards)

This chart gives the salary boundaries of engineers who have supplemented a standard technical education of college grade, by at least a full year of graduate technical work at a recognized engineering college. As teachers are included, salary levels may be influenced by the large number of academic men in this educational group. Note the relatively strong position of earnings at the boundary of the lowest 10 per cent.

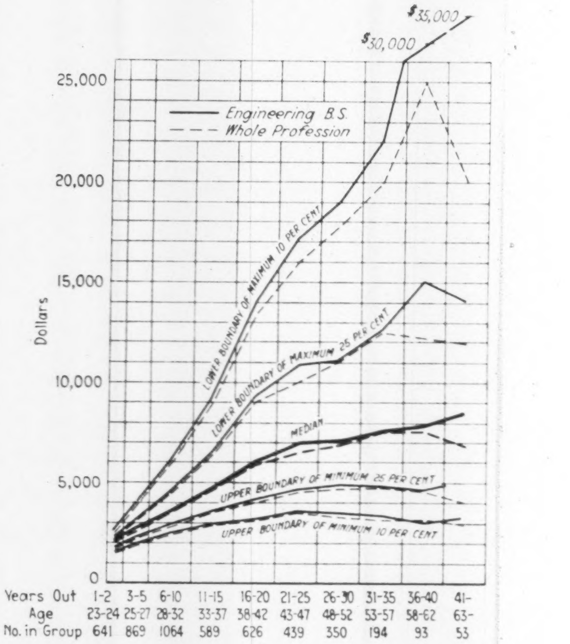


Fig. 19 Salary Boundaries of Engineers With Collegiate Technical Education

(compared with general professional standards)

This group includes only men who have received a B.S. degree from an engineering school of recognized college rank. So large a proportion of younger engineers are in this group that its earnings almost set the levels for the profession as a whole until the later age groups where there is a larger proportion of men with education of less than college rank.

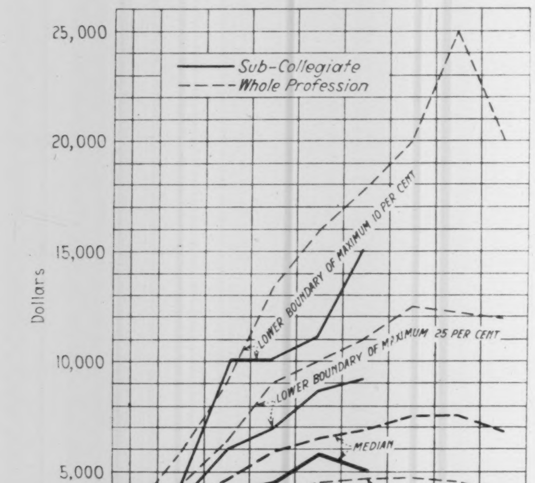


Fig. 20 Salary Boundaries of Engineers With Technical Education of Less Than College Rank

(compared with general professional standards)

Only men who had had at least three years' training in a night school or other technical school of less than college rank are included in this group. The median and lower salary boundaries are so far below those of the profession as a whole that care must be taken to compare them with the correct general professional boundaries.

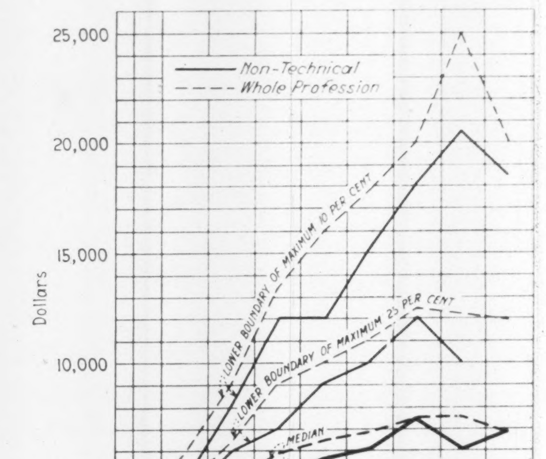


Fig. 21 Salary Boundaries of Engineers Without Technical Education

(compared with general professional standards)

This group includes both men who have had no formal technical training and those whose training has comprised less than three years. It does not include men with correspondence-school degrees. The correspondence-school group was so small as to be negligible. There were not enough men who went to arts colleges or supplemented an arts degree with an engineering degree to give reliable salary figures.

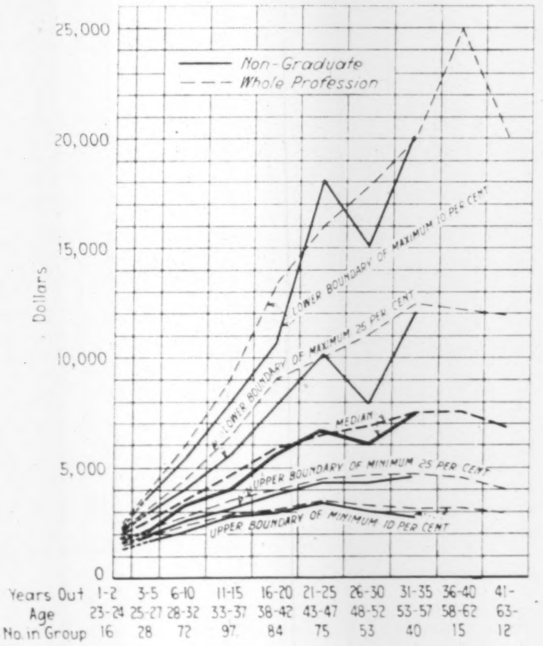


Fig. 22 Salary Boundaries of Engineers With Incomplete Collegiate Technical Education

(compared with general professional standards)

As this group includes only men who had a full three years' work at an engineering school of college rank but who did not receive their degree, it is likely to contain more men who "failed" than those who dropped out voluntarily. Most men who drop out because of financial or other reasons than scholastic standing probably do so earlier in their college course. If they have stood well for three years they are likely to find means to stay the additional year required to get their degree. In view of this fact, it is rather striking how much better their earning power is at most ages and salary boundaries than that of men with sub-collegiate training.

General Smuts's Scientific World Picture

It was our privilege to present in abstract in the October issue a translation of an address by Prof. R. Plank in which was set forth the tendency in modern science for physics to merge with metaphysics. Since the delivery of Professor Plank's address, General Smuts, as president of the British Association for the Advancement of Science, has given to that body a scientific world picture of today in which an interesting attempt is made at establishing a harmonious synthesis of the physical, biological, and social and mental sciences. The complete text of General Smuts's address appeared in the September 25 issue of *Science*, and should be read by all engineers who retain an open mind and an inquiring attitude toward the twilight zones of scientific and philosophic speculation.

General Smuts shows how common sense has separated the phenomena of matter, life, and mind. Science made its first advances in the realm of physics, where measurement and experimentation were most easily effected, and, in the nineteenth century, arrived at a materialistic understanding which had grave effects on contemporary thought. Into this well-intrenched system of physics, with its matter, forces, energy, and time as distinct entities, Minkowski introduced the space-time concept that has been productive of such a rich growth in physical science and as a result of which, it seems to General Smuts, space-time will become the only physical reality, matter and energy having become mere configurations of it.

No sooner, however, had the world accustomed itself to the concept of a space-time continuum than Max Planck established the essentially granular nature of energy in the quantum, a whole-or-nothing particle quite inconsistent with the continuity of space-time. Therefore, General Smuts states, we are confronted with the necessity of working out a new system of concepts better suited to this new world. Thus has the common-sense view of the material world been shattered.

Turning next to the biological sciences, General Smuts finds in the theory of organic evolution an important biological discovery in which the time aspect of the world finds its most authentic expression. The world, he says, "truly becomes process..... a growing creative stream of unique events." In this process of organic evolution new structures, organs, functions, and powers have appeared which have culminated in "the master key of mind and in the crowning achievement of human personality."

Comparing now the physical with the biological, General Smuts sees that in the former time is neutral as regards direction, while in the latter it has direction, a forward flow. Cosmic evolution, which tends toward disorganization and disintegration, as expressed in the Second Law of Thermodynamics, is in an opposite direction to that of organic evolution which shows a forward movement toward higher organization and rising qualities. "Life and mind," he argues, "thus appear as products of the cosmic decline."

Further comparisons lead to the conclusion that "the quantum in the physical world offers an analogy to life," as each behaves as an indivisible whole and neither falls within the deterministic causal scheme. "Life is not an entity.....it is a type of organization." Life and the quantum "behave as wholes." Continuing this line of reasoning, General Smuts comes to the conclusion that "it would almost seem as if the world in its very essence is 'holistic,'" i.e., composed of wholes rather than of parts. Interaction in matter as in life "is not so much mechanical as organic or holistic;" and thus a death blow is dealt to the materialistic creed and a basis is laid for a new scientific monism.

General Smuts next shows that mind is a "potent embodiment of the organizing, whole-making principle," "nature's supreme organ of understanding, endeavor, and control." "The free creativeness of mind is possible because.....the world ultimately consists, not of material stuff, but of patterns, of organization, the evolution of which involves no absolute creation of an alien world of material from nothing."

Summarizing. General Smuts's first point is that "physical science reaches a microscopic world of scientific entities very different in behavior from the macroscopic world of matter, space, and time," and as we pass from physical to biological, and finally to mental levels, we find them all genetically related, in a growing, evolving, creative universe.

Next, if matter is "immaterial structure or organization it cannot fundamentally be so different from organism, or life, which is best envisaged as a principle of organization, nor from mind, which is an active organizer."

Thirdly "the iron determinism of the older science has been materially recast," and we are thus justified in stressing "an increasing measure of freedom and creativeness in the world, sufficient, at least, to account for the appearance of moral law and endeavor."

Finally, it appears that "while the stream of physical tendency throughout the universe is on the whole downward, toward disintegration and dissipation, the organic movement, on this planet at least, is upward." "In its organic aspects, the universe is on the way to life and mind." "Are we not," he asks, "in the emergence of life and mind, witnessing the birth or revelation of a new world out of the macroscopic physical universe?"

The principal implications of General Smuts's address are found in the following concluding paragraphs.

"Piecing together these clues and conclusions we arrive at a world picture fuller of mystery than ever. In a way it is closer to common sense and kinder to human nature than was the science of the nineteenth century. Materialism has practically disappeared, and the despotic rule of necessity has been greatly relaxed. In ever-varying degree the universe is organic and holistic through and through. Not only organic concepts, but also, and even more so, psychological viewpoints are becoming necessary to elucidate the facts of science. And while the purely human concepts, such as emotion and value, purpose and will, do not apply in the natural sciences, they retain their unimpaired force in the human sciences. The ancient spiritual goods and heirlooms of our race need not be ruthlessly scrapped. The great values and ideals retain their unfading glory and derive new interest and force from a cosmic setting. But in other respects it is a strange new universe, impalpable, immaterial, consisting not of material or stuff, but of organization, of patterns or wholes which are unceasingly being woven to more complex or to simpler designs. In the large it appears to be a decaying, simplifying universe which attained to its perfection of organization in the far-distant past and is now regressing to simpler forms—perhaps for good, perhaps only to restart another cycle of organization. But inside this cosmic process of decline we notice a smaller but far more significant movement—a streaming, protoplasmic tendency; an embryonic infant world emerging, throbbing with passionate life, and striving toward rational and spiritual self-realization. We see the mysterious creative rise of the higher out of the lower, the more from the less, the picture within its framework, the spiritual kernel inside the phenomenal integuments of the universe. Instead of the animistic, or the mechanistic, or the mathematical universe, we see the genetic, organic, holistic universe, in which the decline of the earlier physical patterns provides the opportunity for the emergence of the more advanced vital and rational patterns.

"In this holistic universe man is in very truth the offspring of the stars. The world consists of not only electrons and radiations, but also of souls and aspirations. Beauty and holiness are as much aspects of nature as energy and entropy. Thus 'in external lines to time it grows.' An adequate world view would find them all in the proper context in the framework of the whole. And evolution is perhaps the only way of approach to the framing of a consistent world picture which would do justice to the immensity, the profundity and the unutterable mystery of the universe."

It may be asked, What has this to do with engineering? The answer is not far to seek. If we substitute for the word "science" the word "engineering," we may paraphrase another of General Smuts's statements by saying that engineering is at last coming into its own as one of the supreme goods of the human race. "Indeed, one of the greatest tasks before the human race will be to link up science with ethical values and thus to remove grave dangers threatening our future."

Recently President Butler, in commenting on the disappearance of the study of the classics from the preparation of students for college, expressed the fear that men of science might, in their absorption with the details and minutiae of their rapidly narrowing specialties, fail, as had the classical scholars of the last century, to find in their studies those vital essentials which relate science to contemporary life and the progress of civilization. This danger confronts the engineer less potently than the scientist, and yet it cannot be said that it does not exist. Engineering is, to borrow General Smuts's word, holistic, or organic. Its parts are nothing if unrelated to the whole, and engineering itself loses its value and its significance if those who practice it, and those who benefit from it, fail to relate it to the well-ordered progress of societal evolution.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

The Liquid Engine

IN STEAM or internal-combustion engines the motive power is provided by the expansion of a gas. In the engine to be described the thermodynamic medium is a liquid. The author asks, "Why a liquid medium?" and answers it by saying that it has been found experimentally that when liquids are made to move correctly in properly dimensioned films with metal walls, an exceedingly high heat-transfer efficiency is obtained. Another reason for the use of liquids is that their dilatation is greater than their compressibility, thus allowing great changes of pressure with small changes of temperature. There is also their freedom from explosive risk, their capacity for generating power from a very small quantity of liquid, and their flexibility of operation and design, together with the fact that all glands and joints are cold.

The essential principle of the new engine is very simple. If we should heat a liquid in a cylinder with a piston the expansion of the liquid upon heating would obviously make the piston move. With an ordinary cylinder filled with a large mass of liquid the action would be very slow. The article shows how the author has overcome this difficulty.

A purely diagrammatic sectional model of an elementary form of the new engine is shown in Figs. 1, 2, 3, and 4. In this model there is provided a strong T.D. (thermodynamic) steel tube kept hot at the closed end by hot gases of combustion and kept cold at the gland end by cooling water or air. This tube contains the T.D. pile, at opposite ends of which are the cold dummy and the hot dummy. The purpose is to provide cooling and heating surface on the inner wall of the T.D. tube for the liquid that comes in contact with it. The T.D. pile is really a thin film of liquid between metal tubes or plates. Plain non-return valves are provided at the cold end.

The T.D. pile, dummies, and valve box are rigidly held together and move as a whole by the small T.D. pile rod operated by the eccentric sheave. This unit, as a whole, forms a displacer, and so forces the liquid through the T.D. pile from the cold end to the hot end, and vice versa, light piston rings at the valve-box end of the cold dummy preventing liquid from passing around the outside of the T.D. pile.

The engine cycle, or one revolution of the crankshaft, is as follows: The ram of the engine cylinder is now at the extreme right end of the cylinder and the T.D. pile at its midstroke, with the pressure at 5.3 tons per sq. in. See Fig. 1.

When the engine shaft is moved the first quarter of a revolution, the ram moves half a stroke out of the cylinder, and the pressure falls to 4.3 tons per sq. in. Simultaneously the T.D. pile moves to the cold end of the T.D. tube. See Fig. 2.

Now the engine shaft is moved the second quarter of a revolution, during which the ram moves to the outward end of its stroke and the pressure falls to 1.4 tons per sq. in. Simultaneously the T.D. pile moves from the cold end of the T.D. tube to its half-stroke position. See Fig. 3.

When the engine shaft is moved the third quarter of a revolution the ram moves half a stroke into the cylinder, and the pressure rises to 2.3 tons per sq. in. Simultaneously the T.D. pile moves from its half-stroke position to the hot end of the T.D. tube. See Fig. 4.

At the end of the fourth quarter conditions have returned to those indicated in Fig. 1.

The liquid moves from the hot end to the cold end during the fourth and first quarter revolutions of the engine shaft, while the pressure rises from 2.3 to 5.3 and falls from 5.3 to 4.3 tons per sq. in., say, an average of 4.3 tons per sq. in.

During the second and third quarter revolutions of the engine shaft the unit formed by T.D. pile, dummies, and valve box will move from the cold end to the hot end of the T.D. tube, while the pressure falls from 4.3 to 1.4 and rises from 1.4 to 2.3 tons per sq. in., say, an average of 2.35 tons per sq. in.

It will be noticed that while the T.D. pile is moved from the hot end to the cold end of the T.D. tube the liquid only moves in one passage of the T.D. pile. During this operation the moving liquid in the T.D. pile takes heat from the metal and stationary water in the T.D. pile, and the water that surrounds the hot dummy takes heat from the heating surface of the T.D. tube. This heat is absorbed at an average pressure of 4.3 tons per sq. in.

When the T.D. pile is moved from the cold end to the hot end of the T.D. tube the liquid only moves in the other passage of the T.D. pile. During this operation the moving liquid in the T.D. pile gives heat to the metal and stationary water in the T.D. pile, and the water that surrounds the cold dummy gives heat to the cooling surface of the T.D. tube. This heat is rejected at an average pressure of 2.35 tons per sq. in.

It will be noticed that the 90-deg. lead of the eccentric ahead of the crank causes the greatest movement and displacement of liquid in the T.D. pile, while the ram moves and displaces least; also that while the ram moves and displaces most liquid the T.D. pile moves and displaces a small amount of liquid.

Hence heat is put into the liquid medium while pressure is rising, due to ram compression of liquid in the fourth quarter revolution of the engine shaft.

While the ram reverses movement heat is put into the liquid medium and causes a rise of pressure.

During the first quarter revolution of the engine shaft heat is put into the liquid medium during a small fall of pressure and a large increase of volume.

During the abstraction of heat from the liquid medium the order is reversed.

Hence, there is no truly adiabatic, isothermal, constant-volume or constant-pressure heating or cooling.

At full power the T.D. pile stroke would be at a maximum, and seven revolutions of the engine shaft would force all the liquid in the T.D. tube once around the T.D. tube circuit.

The power of the engine is controlled by the alteration of the last stroke of the T.D. pile.

The reversibility of the engine is controlled by two sheaves and a link motion, similar to a steam engine.

The first small engine used mercury as a medium. The first large engine had a few days' run with oil as the medium, and all the engines since have used water as the medium. For practical purposes water is considered to be best.

The author describes in some detail the regenerator or T.D. pile. This is built up of concentric tubes with the water films between each tube. Piles of laminar construction have also been built. Incidentally, it is stated that one pile and tube has run more than 20,000,000 revolutions without anything having been touched.

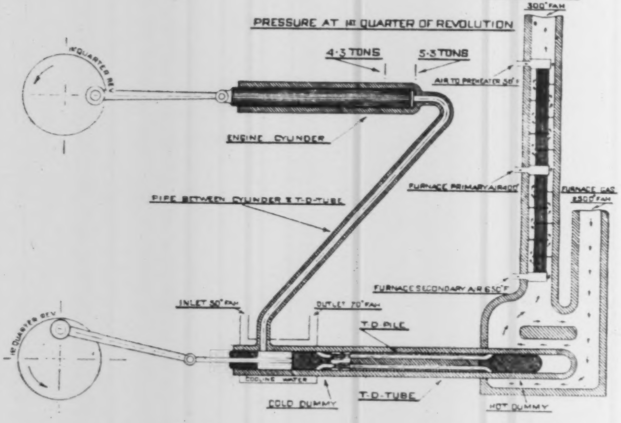

FUNNEL WASTE GAS
300° FAH
PRESSURE AT 1ST QUARTER OF REVOLUTION
4·3 TONS
5·3 TONS
1ST QUARTER REV
AIR TO PREHEATER 50° F
ENGINE CYLINDER
FURNACE PRIMARY AIR 400°
FURNACE GAS
2500° FAH
PIPE BETWEEN CYLINDER & T-D-TUBE
FURNACE SECONDARY AIR 650° F
INLET 50° FAH
OUTLET 70° FAH
T-D-PILE
1ST QUARTER REV
COOLING WATER
T-D-TUBE
COLD DUMMY
HOT DUMMY

Fig. 1 Liquid Engine at Fourth Quarter of Revolution

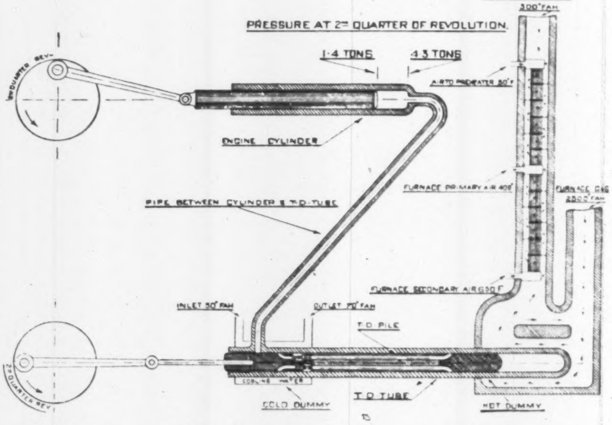

FUNNEL WASTE GAS
300° FAH
PRESSURE AT 2ND QUARTER OF REVOLUTION.
1·4 TONS
4·3 TONS
1ST QUARTER REV
AIR TO PREHEATER 50° F
ENGINE CYLINDER
FURNACE PRIMARY AIR 400°
FURNACE GAS
2500° FAH
PIPE BETWEEN CYLINDER & T-D-TUBE
FURNACE SECONDARY AIR 650° F
INLET 50° FAH
OUTLET 70° FAH
T-D-PILE
2ND QUARTER REV
COOLING WATER
T-D-TUBE
COLD DUMMY
HOT DUMMY

Fig. 2 Liquid Engine at First Quarter of Revolution

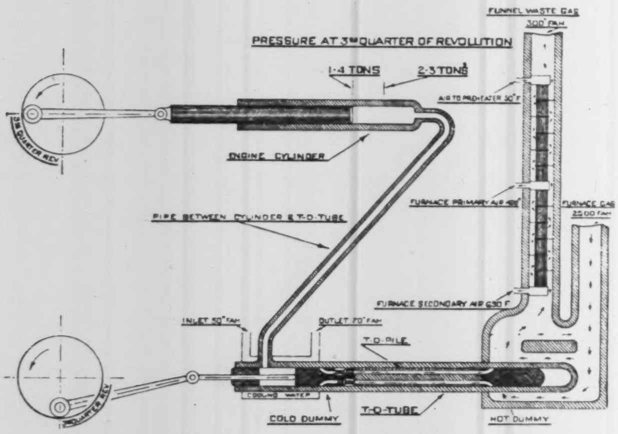

FUNNEL WASTE GAS
300° FAH
PRESSURE AT 3RD QUARTER OF REVOLUTION
1·4 TONS
2·3 TONS
AIR TO PREHEATER 50° F
ENGINE CYLINDER
FURNACE PRIMARY AIR 400°
FURNACE GAS
2500° FAH
PIPE BETWEEN CYLINDER & T-D-TUBE
FURNACE SECONDARY AIR 650° F
INLET 50° FAH
OUTLET 70° FAH
T-D-PILE
COOLING WATER
T-D-TUBE
COLD DUMMY
HOT DUMMY

Fig. 3 Liquid Engine at Second Quarter of Revolution

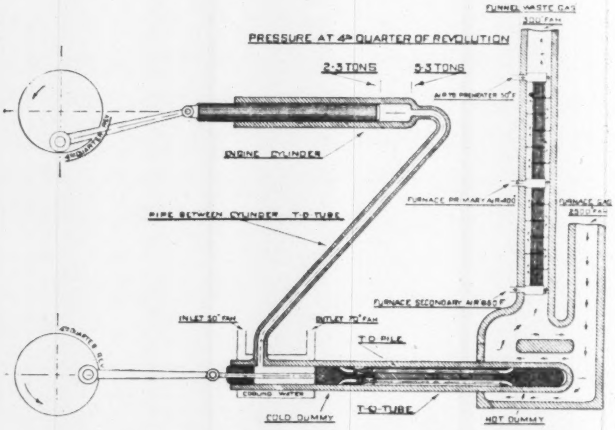

FUNNEL WASTE GAS
300° FAH
PRESSURE AT 4TH QUARTER OF REVOLUTION
2·3 TONS
5·3 TONS
AIR TO PREHEATER 50° F
ENGINE CYLINDER
FURNACE PRIMARY AIR 400°
FURNACE GAS
2500° FAH
PIPE BETWEEN CYLINDER T-D TUBE
FURNACE SECONDARY AIR 650° F
INLET 50° FAH
OUTLET 70° FAH
T-D PILE
COOLING WATER
T-D-TUBE
COLD DUMMY
HOT DUMMY

Fig. 4 Liquid Engine at Third Quarter of Revolution

The face of the T.D. pile at its cold end is so arranged that every alternate film of liquid moves in a similar direction at the same instant; the two non-return valves decide which of the two groups of liquid films shall move or stand still.

The T.D. pile has a uniform temperature gradient along its length.

For any specified efficiency of an engine using the same design of liquid film the speed of the film will be approximately constant; hence the required revolutions per minute of the engine at full power determines the length of the T.D. pile.

The thickness of the liquid film of one T.D. pile was 0.01 in. The engine that used this pile had an indicated efficiency between heat and work of about 30 per cent.

Any type of fuel can be burned in an external-combustion furnace and the hot gases of combustion conveyed to the heating unit.

The furnace is supplied with preheated air, the primary supply being taken halfway down the preheater at the highest safe temperature, the secondary supply being taken from the hot end of the preheater.

The preheater is heated by the waste gases that leave the heating unit and pass, via the preheater, to the stack and so to the atmosphere.

The heating unit has a mechanically operated gas circuit, which takes a weight of hot gas at maximum temperature into itself from the furnace, and rejects from itself the same weight of gas at the coldest part of the gas circuit.

The gas circuit at its coldest part ejects some of the gases into the preheater; the remainder moves further around the gas circuit at its lowest temperature, and takes into itself some of the furnace gases at their hottest temperature; the resultant mixture at a medium temperature circulates around the hot ends of the T.D. tubes, and in heating the tubes, and therefore the liquid inside them, cools the heating gases; these cooled gases move around the circuit either to the preheater or to mix again with the hot furnace gases.

Hence the gas circuit is heated to a moderate temperature by an influx of very hot gases and cooled by the T.D. tubes.

This method of only allowing a moderate temperature of gas to make contact with the T.D. tubes effectively prevents them from being overheated. It means that convected heat rather than radiant heat is what is desired; this requires a relatively large heating surface and a relatively small amount of heat absorbed per square foot of heating surface.

The expansion of the liquid either in the T.D. pile or at the heating surfaces at the hot end of the T.D. tube is passed right through the liquid to the end of the ram in the engine cylinder. As no liquid can leave the T.D. tube without passing the cooling surface, it means that the engine cylinder and the liquid in it are always cold.

The liquid medium needs to be a mobile liquid between atmospheric temperature and a temperature at which steel has an economic strength. Next, it should have a stable and level specific heat. Its compressibility should be proportionate to its dilatation, it should be a stable compound not easily dissociated chemically, and it should not be explosive, poisonous, nor too easily burnt. Many liquids have been tested and most of their physical properties valued, but for practical purposes water is at present the best medium known.

The author describes next the experimental engine. This had 80 T.D. piles operated by a cam, which meant that for every alternate quarter of a revolution the T.D. piles remained stationary for a quarter of a revolution. The speeds varied between 24 r.p.m. and 180 r.p.m. He describes next the small horizontal engine which was built in 1927. Here the speeds varied between 40 r.p.m. and 250 r.p.m. A vertical engine is also illustrated in the original article. The author says that the average of three brake trials by three different engineers gave 27 per cent indicated efficiency. An illustration in the original article shows the 1930 vertical engine. The advantages of the engine are enumerated in some detail.

In the discussion which followed, the chairman of the meeting, Llewllyn B. Atkinson, said that he had seen these engines in Newcastle. The two large ones were not running when he saw them but the smaller one was running and it was fitted up in such a way that one could note the different operations, such as consumption of gas and temperature and pressure in every part of the engine. He had seen the engine raised and lowered in speed in a few seconds, turning over from almost full speed, and running more noiselessly, the speaker thought, than any engines of any kind whatever that he had known. After studying the engine it seemed to him that one of the reasons why there was such little loss of heat was this: one had not got in the boiler part a whole lot of things that were hot and had to be insulated. The engine seemed absolutely cool—much cooler than a gasoline engine of similar power or than any steam engine. The heat was confined to the burning gas and the hot ends of the tubes; all the rest seemed cool. It seemed to the speaker that that was the reason for such a small waste of heat; and it was not a thermodynamic waste, it was a pure conduction waste.

In answering a question as to the load on the brake, Mr. Malone, the inventor, said that the engine could not be run without a load. The last engine would be up to about 50 b.hp.

According to Alan E. L. Chorlton, the cycle of the new engine was really a temperature one similar to that of engines working with hot air, but with a liquid instead of a gas, which raised the mean effective cylinder pressure and thus made it possible to get more out of the engine than the old hot-air mean pressure gave.

It was brought out that the engine had run for more than 300 days at about 12 hr. a day. The weight is 330 lb. per i.hp. The power was approximately 3 i.hp. per tube, and the maximum power that had been obtained from the engine having twenty tubes was between 50 and 60 i.hp. The ram was $2^1/_4$ in. in diameter and 18 in. stroke. The engine has only two glands—one in the cylinder and one supplying a nest of tubes. Each tube does not have a gland. As regards leakage past the gland, the latter has to be designed in accordance with the new practice, as otherwise there would inevitably be leaks. (J. F. J. Malone in *Journal of the Royal Society of Arts*, vol. 79, no. 4099, June 12, 1931, pp. 680–703, 17 figs., and discussion pp. 703–709, *dA*)

Short Abstracts of the Month

AERONAUTICS

Some New Features of Engines Exhibited at the National Aircraft Show

THE smallest engine at the show was the Heath-Henderson, a 4-cylinder vertical air-cooled engine developing 27 hp. at 3000 r.p.m. and weighing 117 lb. when equipped with accessories and propeller.

A horizontally opposed L-head-type air-cooled engine in the 30-hp. class was shown as a 4-cylinder job by the Continental Motors Corporation (Model A-40). The cylinders are cast in pairs, as are the cylinder heads.

The Poyer Model 3-40 is a 3-cylinder radial air-cooled engine developing its rated power at 2500 r.p.m. and weighing 125 lb. with single ignition. It uses slipper-type connecting rods which automatically give all pistons the same stroke. Bronze bushings are provided to decrease the friction caused by the oscillating movement of the lower ends of the rods with respect to each other. The cylinders are adjustable, the compression ratio available varying from 5 to 1 to 8 to 1. This can be changed by turning the adjustment ring at the base of the cylinder, for which a special tool is provided.

The valves are operated by a patented planetary valve mechanism operated directly from the crankshaft. Large-diameter rollers built integral with the revolving gears travel along the cammed end of the valve lifters and give the valves a very smooth and gradual acceleration. Side friction of the valve-follower guides is so low due to this method of operation that special steel bearing surfaces are not necessary. The oil tank is connected directly to the crankcase, and its finned surface is exposed to the slipstream to cool the oil.

In the Kinner engine (100, 125, and 210 hp.), shrouding of the bush rods and valve-operating mechanism is used to insure better lubrication for these parts. In the larger engine H-type master link rods have been provided. It is claimed that although this construction may increase the weight of these parts slightly, machining costs are reduced materially, thus justifying the change. Lightening holes parallel to the pin bushings are drilled through the mass of metal directly inward from the bearing hubs at the end.

The Menasco line, which was also shown for the first time, is composed of a series of three engines, covering the range of 90 to 160 hp. An analysis of the specifications of two of their engines of the same overall size discloses some interesting facts, the most useful one being how low weight per horsepower may be achieved. The more refined engine of these two develops approximately 30 hp. more than the standard model, with no increase in weight. Although some weight may have been saved by the lightening of overstrong parts, downdraft carburetion, improvements in manifolding, higher compression ratio, and a slight increase in bore and in revolutions per minute provide the additional horsepower.

The Lambert Model 90 engine is of the radial type, and yet contains no centrifugal supercharger or diffuser. To overcome the unevenness of fuel distribution that ordinarily occurs in radial engines not equipped with such auxiliary mechanisms, a diaphragm is cast to the manifold between the No. 1 and No. 5 cylinders. This diaphragm has a compensating hole to allow some gas to flow through and equalize any unevenness in gas pressure that may occur. The size of this hole may be increased by drilling into the manifold from the rear and taking part of diaphragm metal away, thus adjusting the amount of gas flow through the diaphragm and accurately balancing the gas flow in the two sections of the manifold, one section of which supplies the charge to two cylinders and the other to three cylinders. It is claimed that this restriction in the manifold produces very even distribution of the intake gas to the various cylinders, thus allowing the upper cylinders to get the proper mixture without having too rich a mixture for the bottom cylinders.

Another feature, used in conjunction with the intake manifold, is the connecting up of the intake passage with the valve-follower guide holes, which are machined directly in the crankcase, by small drilled holes, thus allowing the partial vacuum existing in the manifold when the engine is in operation to draw off the excess oil from the valve followers, and preventing it from being pumped to the outside of the engine.

Several other types are described in the original article. In the Packard Diesel engine no means were provided whereby the intake air could be throttled, thus allowing the engine to continue to run on lubricating oil after it was warmed up, and preventing its slowing down when landing. To overcome this handicap a duralumin valve similar to the throttle in a carburetor was added to the venturi through which the intake air passes, this valve performing the function of restricting the opening for the intake air when the fuel control is set for idling or low-engine-speed conditions.

The effective shape of the combustion chamber has also been changed by altering the depression machined into the piston head. This change allows better penetration of the fuel, and produces a better turbulence condition, aiding in the distribution of the fuel. The consequent better combustion is so complete that smoking, which sometimes occurred with the previous design, has been eliminated.

In the Curtiss-Wright engines new cylinder heads are used, and the exhaust gases are now taken out through the side of the head through a detachable finned casting. Patented spark-plug coolers consisting essentially of a finned shell held in place by the spark plugs are used and, it is claimed, contribute to the reduction to the maximum temperature reached by these parts. On the Cyclone engines special baffles are attached to the engine directly in back of and between the cylinders to deflect the air stream around to the back of the cylinder barrels to cool the rear half of the barrel more nearly in proportion with the front half. (C. H. Schowalter, Lawrance Engineering and Research Corporation, in *Aviation Engineering*, vol. 4, no. 6, June, 1931, pp. 9–15, illustrated, *d*)

CORROSION

Valve Corrosion, Design, and Lubrication

The various factors entering into the selection of valves for industrial applications are here considered, particularly with regard to possible corrosion and disturbance of valve operation. This article does not apply to valves in steam or internal-combustion engines.

The matter of corrosion must be considered, together with all other factors of operation such as availability of the metals selected. In certain instances where heavy corrosion is present, special metals, such as stainless steels or complex copper alloys, may be economically desirable. Special metal trim or the use of specially treated parts at points where the greatest corrosion or erosion is experienced may be advisable.

From the standpoint of resisting corrosion, the plug-cock type of valve possesses inherent advantages. In this type of valve, when fully opened, no part of the machined surfaces of the valve is exposed to the corrosive or erosive action of the line fluid. When in the closed position, while a portion of the plug is exposed to the action of the line fluid, this area of the plug does not form a part of the machined surfaces which must be brought in contact to effect a shut-off.

Another advantage of the plug-cock design is the fact that it offers a smooth passageway through the port with no opportunity to collect pipe scale, etc., in the seat as is the case with a gate valve. The effectiveness, however, of the unlubricated plug cock in combating corrosion and erosion is largely theoretical unless means are provided to prevent the entry of the line fluid between the machined surfaces or into other portions of the valve where it may exert an unfavorable influence. Because of the fact that the plug cock is the only common form of valve in which the contact surfaces are not exposed to the action of the line fluid, this type also lends itself admirably to the idea of pressure lubrication. The plug cock, then, is a form of valve which, because of its design, offers the most effective natural resistance to corrosion and erosion, and which is ideally suited to the application of pressure lubrication. Without lubrication, however, the use of the plug cock is limited principally to small sizes because of the practical difficulty of operating large ones, especially when exposed to corrosive influences. To the operator in the field, this is evinced simply by a rusting and consequent sticking of the plug.

It is assumed that a lubricant is available which is adequately resistant to the chemical action of the line fluid and to the temperature to which it will be subjected, and is of sufficient viscosity to make it effective as a sealing medium. This offers an effective means, when properly applied under pressure in the plug cock, of combating corrosion in the valve, of reducing the friction incidental to the operation of the valve, of sealing the valve against leakage, and of freeing the plug, in case it is stuck, by employing the lubricant as in a hydraulic jack on the base of a tapered plug. By means of pressure lubrication not only are the smaller sizes of plug cocks made more easy of operation, but the manufacture of plug cocks in large sizes, formerly considered impracticable, is made more practicable. Today there are in operation on a number of gas lines 30-in. (76.2-cm.) plug cocks which may be operated with all the ease of a small plug cock.

The opinion has been advanced that the somewhat lower hydraulic efficiency of the conventional form of plug cock with rectangular port, as compared with that of the gate valve, is a disadvantage. However, it may be easily shown that the hydraulic loss incurred by any form of valve is generally a very small or fractional percentage of the hydraulic loss incurred in other parts of the pipel ine or system. This is particularly true when handling gas or vapors under high pressures, or when handling liquids under a high static head. This lower hydraulic efficiency is easily offset by the greater reliability and inherent ruggedness of the lubricated plug cock. The cost of the lubricated plug cock when compared with a gate valve is generally less in the smaller sizes, but in the larger sizes the spread turns somewhat in favor of the gate valve. This comparison, however, does not hold strictly when other factors are taken into consideration, such as the use of more expensive metals and also the application of valves of reduced port area where the greater hydraulic loss through the use of such a reduced-area valve is a negligible part of the total head lost either in pumping through a long length of pipe line or against a high static pressure.

The ability to renew the lubricant in pressure lubrication of a plug cock offers a means of sealing the valve against leakage by renewing the seating surface after it has become worn. In one form of lubricated plug valve the lubricant under pressure is used to free the plug in case it is stuck by means of a multiple hydraulic pressure applied to the base of the plug. To be successful the lubricant must be uniformly distributed over the contact surfaces of the valve, and this distribution must be secured without distortion of the valve body by means of excessive lubricant pressures. The proper distribution of the lubricant must be achieved by the proper proportioning of the lubricant ducts and their arrangement in the valve. Furthermore the metal contact surfaces of the valve should never be separated without their being concurrently filled with lubricant. The matter of selection of lubricant is next considered. (Geo. F. Scherer, Merco Nordstrom Valve Co., San Francisco, Cal., in a paper presented before the Western Metal Congress, San Francisco, Feb. 16–20, 1931, abstracted through *Industrial and Engineering Chemistry*, vol. 23, no. 9, Sept., 1931, pp. 986-989, *p*)

ENGINEERING MATERIALS

The Cost of Finished Steel

THE present article deals mainly with plant No. 2 of the Inland Steel Co., located at Indiana Harbor, Ind. It is of interest because it gives detailed figures for the mill items that affect the cost of steels. The cost of ore is said to be $4 per short ton, and itemized figures for taxes, royalty, mining, and freight are given.

It costs most companies $1.50 to mine coal. After paying freight and handling, storage, etc., a good average cost for Chicago coal is $4.50. The yield of coke in a by-product plant is 68 per cent, bringing the cost per ton of coke to $6.75 before crediting the value of by-products. The market for these by-products has suffered severely, has dropped from about $2.75 per ton of coke to $1.75, and has thus raised the cost of the coke from about $4 to about $5 a ton. There are charged 1750 lb. per ton of iron.

Seven hundred and fifty pounds of limestone are used per ton of iron at a cost of some 45 cents per ton, and the operation of a blast furnace costs $1 for labor and about $1.40 for supplies, repairs, and relining. Blast-furnace gas is charged to other operations at a credit of $1.10 per ton. This brings the cost of a ton of pig iron to $14.50.

In the open hearth there are used approximately 1100 lb. of pig iron and 1100 lb. of scrap per net ton of ingots produced. At the present time scrap at the plant costs approximately $11 per ton, and the metal charge per ton of ingots produced is about $14. The cost of additions is about $1 per ton. Labor, supplies, fuel, etc. amount to $5 per ton, thus bringing the cost of ingots to about $20 per ton. The blooming cost is about $1.50 a ton, to which should be charged the cost of a loss of 13 per cent through cropping the ends and scaling of hot metal, leaving the total cost of blooming at $3 per ton. [This is an average figure, as in open steel the cropping loss is much smaller, while in rail steel, of which a large amount is made at Inland, the cropping loss is greater than 13 per cent.] Reducing the bloom to billets entails a further cost of $1 and a 5 per cent scrap loss costing about 50 cents net. For the manufacture of sheets, billets are reduced to sheet bars at a cost of $1.50 and a further scrap loss of 50 cents.

The introduction of new continuous sheet and strip mills is radically changing the nature and cost of sheet production. The new process makes a reduction of about $5 in production costs from those already stated, and in addition produces much better sheets. With these the old sheets can hardly compete in many markets, regardless of cost. Sheets are measured by gages—the higher the gage, the thinner the sheet. The old rule-of-thumb was $1 rolling cost per gage, which has generally been bettered in many mills. For instance, 24-gage is a standard price-basing size, and costs about $22 to roll, of which $15 represents direct and indirect labor, $4 represents repairs and maintenance, and $3 represents general supplies, heat, power, and miscellaneous overhead. Scrap loss is a further cost of $2, making a total conversion cost from sheet bars to sheets of $24, and total cost of about $50.

An integrated steel plant requires a fixed investment of some $75 per ton of normal production of finished products, and a total capital employed of at least $100 per ton. A well-maintained steel plant in general has a physical life beyond its probable useful life, as obsolescence of methods and fundamental economic changes affect demand. Depreciation rates are therefore a matter of business judgment rather than a measure of physical life. The Steel Corporation has written off an average of some $4 per ton of shipments, which seems to be no more than adequate to keep up with these fundamental changes. If one considers that a steel mill, regardless of its capitalization, should earn 6 per cent on the investment, interest amounts to $6 a ton in normal times. The interest charges of the leading steel producers for the past eight years have averaged $2 per ton of finished products shipped. Thus it will be seen that depreciation and bond interest amounting to $6 per ton in normal years would, in a year like the present, when most mills are operating at less than one-half their normal rate, be more than double the customary figure, or at least $12 per ton. Thus with a total cost ranging from $55 to $65 per ton, and with the price of steel sheets precariously maintained at $50 per ton, it is obvious that this branch of the steel business is now being conducted at a severe loss. (*Fortune*, vol. 4, no. 3, September, 1931, pp. 41–50 and 102, 104, and 107, illustrated, *g*)

FUELS AND FIRING

Production of Liquid Fuel From Water Gas

THERE appear now to be three main sources of production of liquid fuel other than crude oil, namely, coal carbonization, hydrogenation of coal under pressure, and production of liquid fuels from water gas. The two former ones are greatly handicapped by the prevailing low prices of oil; as to water gas, the situation is more complicated. Successful synthesis on a manufacturing scale of methyl (wood) alcohol from carbon monoxide and hydrogen under pressure has been successfully accomplished, and is a very simple process. As a liquid fuel, however, methyl alcohol is not very suitable, because of its low calorific value. Various investigations have been carried out on the synthesis of higher alcohols from water gas, and, for example, F. Fischer succeeded in obtaining from water gas an oily product which he called synthol and which consisted mainly of oxygenated substances such as alcohols, aldehydes, ketones, acids, and esters. The products separated into aqueous and oily layers, and almost the whole of the oily layer after removal of acids was suitable as a fuel. It appears that the character of the products depends on the temperature and, particularly, pressure at which the process is carried out. The article deals with the catalysts used in the process and the various temperatures at which the reaction is carried on.

At first it was thought that the products of reaction consisted mainly of saturated hydrocarbons, but it was later found that considerable amounts of olefines were formed, and cases were found where the proportion of unsaturated hydrocarbons was greater than that of the saturated. Equations showing the production of olefines and saturated aliphatic hydrocarbons are given in the original article. From these equations the maximum yield of hydrocarbons can be calculated. The effect of conducting the synthesis at a higher temperature was to increase the proportion of heavy hydrocarbons in the liquid product. In the latest work of Fischer about 80 per cent of the liquid product consisted of benzine boiling below 200 deg. cent. From the data given in the original article it does not appear that any of the processes thus far developed would be commercially applied in the face of the present competition of gasoline. (R. Taylor, in *Chemistry and Industry*, vol. 50, no. 27, July 3, 1931, pp. 580–584, *g*)

Fuel Problems and Practice in Great Britain

THE July 3rd issue of *Chemistry and Industry*, which is a special publication of the Society of Chemical Industry, Great Britain, and associated organizations, is devoted to fuel problems.

In discussing the reasons why the coal industry suffers today, C. H. Lander, Director of Fuel Research, Department of Scientific and Industrial Research, points out that less fuel is used for various purposes than before. In 1913 the Authorized Gas Undertakings used 194 lb. of coal per 1000 cu. ft. In 1927 they used 161 lb. of coal or coke per 1000 cu. ft., with the result that they produced 246.1 million units of gas (1000 cu. ft. per unit) as against 187.6 millions of similar units, but used only 17.7 million tons of coal or coke as compared with 16.3 million in 1913. In 1918 the coal consumed per kilowatt-hour in the electricity supply works was 3.47 lb.; in 1928 it was 2.06 lb. In 1913, 2.06 tons of coal, including the coal equivalent of the coke used, were used per ton of pig iron produced; in 1927 this figure was reduced to 1.84 tons (pp. 546–548).

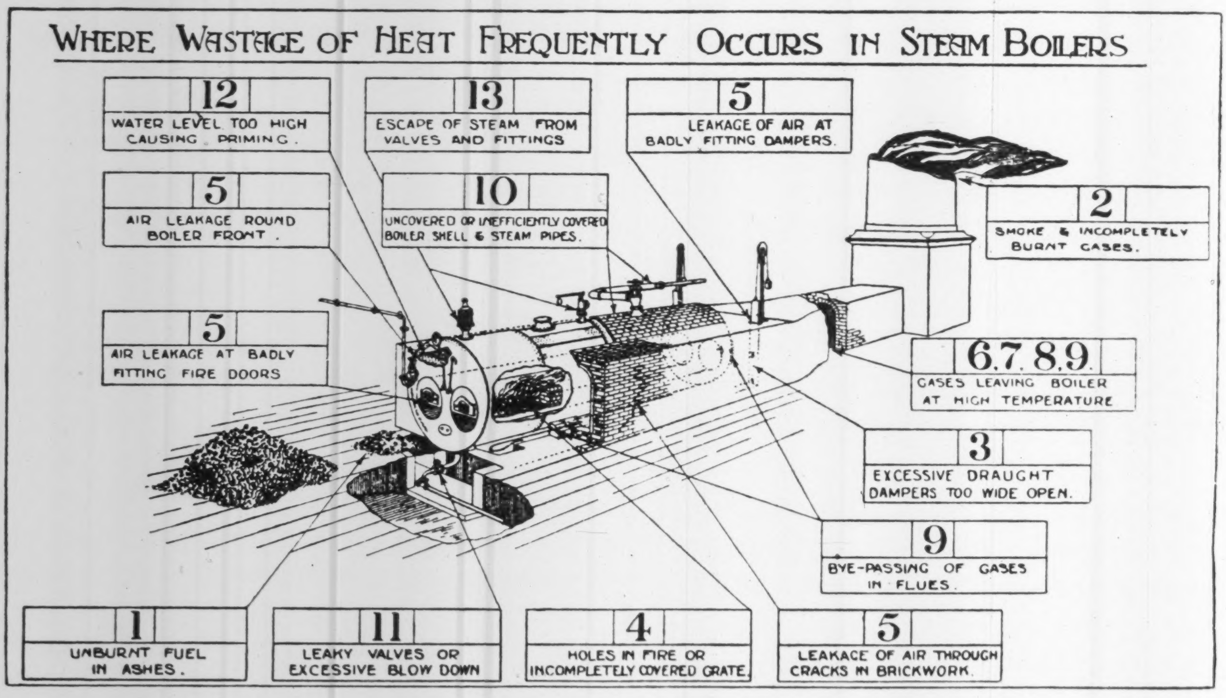

WHERE WASTAGE OF HEAT FREQUENTLY OCCURS IN STEAM BOILERS
12
WATER LEVEL TOO HIGH CAUSING PRIMING.
13
ESCAPE OF STEAM FROM VALVES AND FITTINGS
5
LEAKAGE OF AIR AT BADLY FITTING DAMPERS.
5
AIR LEAKAGE ROUND BOILER FRONT.
10
UNCOVERED OR INEFFICIENTLY COVERED BOILER SHELL & STEAM PIPES.
2
SMOKE & INCOMPLETELY BURNT GASES.
5
AIR LEAKAGE AT BADLY FITTING FIRE DOORS
6.7.8.9.
GASES LEAVING BOILER AT HIGH TEMPERATURE
3
EXCESSIVE DRAUGHT DAMPERS TOO WIDE OPEN.
9
BYE-PASSING OF GASES IN FLUES.
1
UNBURNT FUEL IN ASHES.
11
LEAKY VALVES OR EXCESSIVE BLOW DOWN
4
HOLES IN FIRE OR INCOMPLETELY COVERED GRATE.
5
LEAKAGE OF AIR THROUGH CRACKS IN BRICKWORK.

Fig. 1 The Fuel-Economy Poster Issued by the Federation of British Industries

1. Avoid wastage of cinders in the ashes by cleaning the fires carefully and by using suitable firebars.
2. Avoid production of black smoke and incompletely burnt gases by regularly and frequently firing coal in small quantities. Keep a proper depth of fire.
3. Regulates the draft by the damper to reduce the excess air. Try to obtain 12 per cent of CO_2 in the chimney gases.
4. Keep the grate properly covered with a level fire. Use the rake when necessary for this purpose.
5. Examine the boiler setting carefully for air leakage, particularly furnace doors, cracks in the side walls, joints between the boiler shell, and brickwork, and the damper slides.
6. Keep the boiler surfaces free from soot and flue dust.
7. Keep the internal boiler surfaces free from scale.
8 Do not force the boilers unnecessarily.
9. Examine the seating blocks and partition walls carefully. Repair if necessary to avoid bypassing.
10. Lag the exposed surfaces of boilers and steam pipes efficiently.
11. Avoid excessive blowdown.
12. Keep the boiler filled to the working level by a continuous and steady feed.
13. Avoid leakages of steam from boiler fittings and valves.

A description of the work of the Federation of British Industries, Fuel Economy Department, forms part of a paper on "Fuel Economy in British General Industrial Practice," by G. W. Andrew, technical adviser of the Federation of British Industries. The Fuel Economy Department was established in 1920 for the purpose of furnishing its members with impartial advice and assistance in the improvement of fuel practice in their work.

Under the heading of publications may be mentioned the ***Fuel Economy Review***, the first issue of which appeared in April, 1921, and is devoted exclusively to information of practical value in connection with fuel technology. The Federation has also issued a boiler-plant monograph and a number of charts and diagrams for the instruction of boiler attendants and plant engineers. A small-scale reproduction of the boiler-plant diagram is shown in Fig. 1.

A majority of inquiries have always had reference to the efficient working of steam-raising plant, and the interchange of data between plants operated under somewhat similar conditions has proved to be extremely useful. In this connection it has been necessary to emphasize the essential difference between thermal and economic efficiency, and to base the latter on the ascertained cost per 1000 lb. of steam available for purposes external to the steam-raising plant.

With regard to steam-raising plant, there is evidence of definite improvement as a result of more careful and systematic attention. The majority of industrial plants have thermal efficiencies, calculated in relation to the gross calorific value of the fuel, of between 60 and 75 per cent when lighting and stand-by losses have been taken into account. The difference between indifferent and good practice with a given plant is of the order of 5 per cent on an efficiency basis, wider discrepancies being usually due to differences in the type of plant, working conditions, or fuel used. High thermal efficiency does not necessarily denote good commercial efficiency, and in the case of plants situated within reasonable distances of collieries it is usually found that the best commercial efficiency is obtained when using the cheaper classes of fuel. The purchase of coal on a calorific basis is extending and offers obvious advantages in connection with the controlled operation of steam-raising plant.

The sale to industrial works of low-pressure steam from generating stations is a recent development which, if successful, may have far-reaching consequences; a matter of comparable importance is the supply on a large scale of surplus coke-oven gas for furnace heating at prices which are competitive with the costs of producer-gas or direct coal firing.

Among the steps which have been taken to obtain more exact works data, the measurement of steam has proved to be extremely useful as a means of affecting economy in use, particularly in cases where a number of separate departments or processes are supplied from a common boiler plant. It is an almost invariable experience that where means of measurement and comparison were systematically adopted, economy is of a relatively high order. (*Chemistry and Industry*, vol. 50, no. 27, July 3, 1931, pp. 550–576, *gd*)

The Action of Hydrogen on Coal

THIS is an abstract of a publication of the Fuel Research Committee of the (British) Department of Scientific and Industrial Research, and is concerned with the action of hydrogen upon coal in its earlier stages and in the absence of complicating factors such as vehicle and of catalysts other than the ash of the coal and the material of the bomb. It was found that the amount of molecular hydrogen which reacted during a bomb experiment was less than 1 per cent of the weight of coal employed, while the properties of the product materially varied from those of the original coal. The tar yield was found to have increased, but the most striking observation was the alteration in the type of coke produced. Whereas the original Arley coal gave a hard, slightly swollen coke, the product yielded a highly swollen coke. When tested for caking by the Campredon method the coal gave an index of 24 for caking, whereas the new product gave 39, or well outside of the normal. Such an increase in caking power is of importance both from the point of view of chemical study and that of possible commercial application, as it is equivalent to a conversion of a non-coking into a coking coal. Further experiments were carried on with the so-called Pooley Hall washed slag, which was of the type known as long-flame non-coking coal with comparatively low ash content.

For comparison with the original coal a portion of each of the products was carbonized in the Gray-King low-temperature assay apparatus. It was found possible to obtain solid products which, on carbonization, yield residues varying from a slightly coherent mass to a hard, dense coke, and even to a highly swollen and porous coke. Although this effect has been obtained by raising the reaction temperature, it is also possible that continued action at the lowest temperature would bring about the same effect. A second point of interest is the increase in tar production. The original coal gave 13.6 per cent of tar, while the products yielded amounts ranging from 16.3 to 19.3 per cent of product, or 14.2 to 16.8 when calculated to 100 parts of the original coal, the latter representing a gain of 24 per cent. The composition of the assay gases furnished a further indication, by the decreasing amounts of oxides of carbon, of the progressive diminution of oxygen in the products.

The results obtained up to this point were considered to be of sufficient importance to be protected by patent, and a provisional specification was filed in August, 1927, and the complete specification (B. P. 301,720) was accepted in December, 1928.

This series of experiments provided sufficient evidence upon which to base a more comprehensive examination of the effect of hydrogen upon a series of coals representative of the main types occurring in this country. A table in the original article gives details of successful experiments and a description of the products, with the exception of the data for anthracite. The percentages of hydrogen which reacted varied considerably from coal to coal.

It is not at all clear whether the state of fusion through which the partially hydrogenated products have passed is necessarily concomitant with their increase of coking power over that of the original coal. The advent of fusion could possibly be due merely to the fusion of the original coal, and might be independent of any interaction of the coal substance with hydrogen. Alternatively, it must be assumed that, as a result of hydrogenation, fusible substances are formed in which the remainder of the coal dissolves on heating, or else that the whole of the coal is modified in such a way that it fuses entirely. There still remains the possibility that fusion could take place as a result of hydrogenation and still not give rise to increased coking power. It may seem that the latter is hardly likely to take place in practice, but some preliminary experiments in which carbon monoxide was used in place of hydrogen indicated that fusion can take place as a result of reduction without increase in coking properties. The remainder of the paper deals with partially hydrogenated products. (Fuel Research Technical Paper No. 29, by A. Crawford, F. A. Williams, J. G. King, and F. S. Sinnatt, published by the Department of Scientific and Industrial Research, Great Britain, abstracted through *The Iron and Coal Trades Review*, vol. 123, no. 3305, July 3, 1931, p. 9, *eA*)

INTERNAL-COMBUSTION ENGINEERING (See also Aeronautics: Some New Features of Engines Exhibited at the National Aircraft Show)

Two-Cycle Possibilities for Portable Diesel Engines

AFTER describing the principal features of 4-cycle and 2-cycle engines and illustrating the main representatives of the latter type, the author proceeds to the analysis of operation of the 2-cycle engine. He believes that it will be in great demand for locomotive, marine, and dredge service for Diesel engines of 200 hp. and larger by reason of possible lower costs, lower weight per horsepower, and less floor space. For smaller engines it is generally considered doubtful whether the 2-cycle can be made more cheaply than the 4-cycle engine of the same capacity.

A properly designed 2-cycle Diesel engine (continuous mean effective pressure of 85 lb. per sq. in. and a maximum mean effective pressure of 100 lb. per sq. in.) will lend itself to a successful burning of asphaltic fuel oils. Experiments indicate that the 2-cycle Diesel engine can successfully burn heavy oils, provided that in the case of the smaller engines the start is made on a lighter oil.

One of the most difficult things connected with the successful development of a high-speed 2-cycle Diesel engine is the proper scavenging of the power cylinders. This problem requires further research.

The author considers as the most efficient way of scavenging that found in the Junkers opposed-piston engine in which the unidirectional flow of scavenging air helps to blow thoroughly the burned gases out of the cylinders with a small expenditure of surplus air. A flow line of circumferential ports aids to obtain an even distribution of the scavenging air.

The Junkers Diesel engine, however, cannot be regarded as a simple engine. The author suggests applying the unidirectional scavenging of the Junkers engine to a single-sleeve-valve engine similar to Ricardo's, but working on a 2-cycle principle, and predicts the proportions and performance for such an engine.

Burmeister and Wain, of Copenhagen, Denmark, have recently placed upon the market a line of Diesel-electric locomotives incorporating the use of 2-cycle Diesel units of the solid-injection type. The author gives a sectional view of this engine, as well as one of the chassis of a small industrial locomotive with a Cummins Diesel engine. (Howard E. Degler, *Motive Power*, vol. 2, no. 8, Aug., 1931, pp. 11–13, 5 figs., *d*)

The Baer Rotary-Valve Engine

THIS engine was invented in Germany by Dr. Alfred Baer, and experimental engines have been tested in various places. The Baer valve fitted to a 6-cylinder engine for experimental purposes is shown installed in Fig. 2. It is a tube of considerable diameter which runs throughout the length of the head and is supported by lubricated roller bearings at the two ends. The two ports through which the gases pass to and from the cylinders run diametrically across the valve, and consequently this port can be driven at only one-quarter crankshaft speed, i.e., at half the speed of an ordinary camshaft. This is important as it greatly reduces the speed at which the valve rubs over the various parts with which it is in contact.

At the front end is the combined chain and geared drive whereby the valve is operated from the crankshaft, together with a pump which circulates water through the interior of the valve.

A leakproof joint between the valve and each cylinder is insured by a most ingenious form of construction. Above each bore there is a short sleeve located by an adjustable finger and this carries a curved shoe bearing against the rotating valve. Light springs keep the shoes pushed upward.

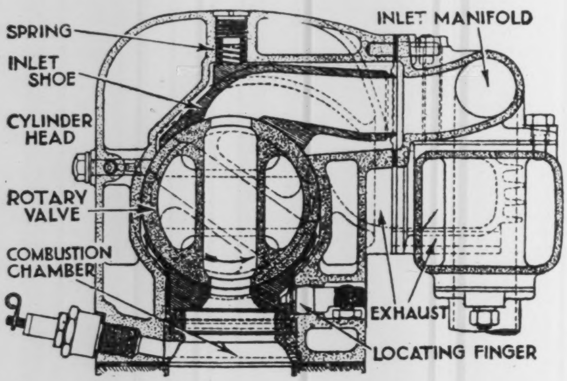


FIG. 2 CROSS-SECTION THROUGH THE HEAD, VALVE, AND MANIFOLDS OF AN ENGINE FITTED WITH THE BAER VALVE

For the exhaust ports it has been found sufficient to use a very fine clearance between the valve and the narrow faces of passages cast in the cylinder head; for the inlet system, however, a tight joint was found necessary, and this is obtained by using a series of shoes bearing against the upper surface of the rotating valve and held in contact therewith by small coil springs. There is, of course, one such shoe for each cylinder, and it embodies a passage through which the mixture passes on its way from the inlet manifold. The free end of each shoe is supported flexibly by means of a thin metal washer.

It is mentioned in this connection that a new English rotary-valve system, namely, the Cross, has recently withstood severe testing. It would therefore seem possible that the poppet valve may experience renewed competition from the Cross and Baer designs. (*The Motor*, vol. 40, no. 1547, Aug. 18, 1931, p. 91, 2 figs., *d*)

LUBRICATION (See also Corrosion: Valve Corrosion, Design, and Lubrication)

Lead Oleate and Border-Line Lubricants

BY THE term "border line" is meant the point at which a straight mineral oil breaks down due to pressure and permits the rubbing surfaces to come into metallic contact. It is stated that an oil compounded with lead oleate will maintain an effective lubricating film beyond the border line of straight mineral oil. Fig. 3 shows graphically the film strength characteristics of a lead oleate lubricant as compared with straight mineral cylinder oil. This graph is said to be based upon actual tests, the two lubricants having the same viscosity.

General specifications for lead oleate compound are given in the original article.

Lead oleate is not the only ingredient which may be used to impart border-line characteristics to a lubricating oil. It is claimed, however, that extensive laboratory and field tests have shown that lead oleate lubricants when properly made are the safest to use. With a lead oleate compound viscosity is important, but not to the same extent as with straight mineral oils. This is illustrated graphically in a curve in the original article.

Lead oleate lubricants absorb moisture and form an emulsion with water to a certain degree. In some cases this is a desirable property, but in most cases it is a disadvantage.

Lead oleate lubricants should be kept from contact with water, but atmospheric condensation may be disregarded in most cases. Tests have shown that for equal viscosities of a lead oleate lubricant and the highest grade of mineral oil the operating temperature of the latter lubricant is slightly lower, while the efficiency of the machine is said to be higher with lead oleate compounds. The reason for this has not yet been determined definitely.

Great care should be exercised in adopting lead oleate lubricants in the industrial field. While this lubricant has undisputed points of superiority, it also has its limitations, especially in regard to its emulsibility characteristics. The main point to remember is that a lead oleate compound is an ideal lubricant for overloaded conditions where the commonly used oils or greases fail to stand up. Where efficient lubrication is being obtained with common lubricants, there is no justification for recommending a more expensive product like a lead oleate compound. Nearly every plant has isolated cases of excessive wear on gears and bearings due to inefficient lubrication; in such applications lead oleate compounds and their derivatives, like special lead oleate greases, will establish for themselves a reputation.

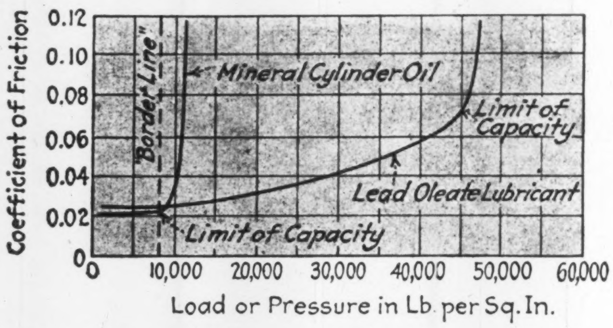
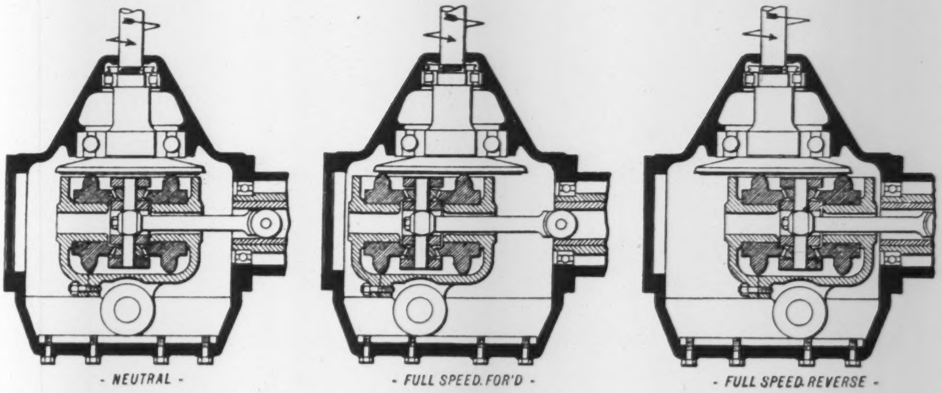


FIG. 3 FILM STRENGTH CHARACTERISTICS OF MINERAL CYLINDER OIL AND LEAD OLEATE LUBRICANT

Lead oleate compounds are giving satisfactory service in many fields. Light-viscosity material is employed in small fractional-horsepower speed reducers, as the operating medium in hydraulic feed mechanisms of the Oilgear type, and in special machines requiring an oil of 175 to 350 sec. viscosity at 100 deg. fahr., and possessing great film strength. Medium-viscosity applications include medium-sized gear-reducer units of the spur, bevel, herringbone, and planetary types; enclosed-type chain speed reducers; and circulating oiling systems for gears and bearings where there is no water condition.

Of the lead oleate compounds, those of heavy viscosity are most used extensively in the automobile and industrial fields. They are employed in worm gears of every size; in reduction gears of every type, including hypoid gears; in flexible couplings of the internal-gear sleeve type; in screwdowns on rolling mills; in mechanical crane brakes of the disk type, etc.

Extra-heavy-viscosity lubricants of this type are used widely in the steel industry for the lubrication of rolling-mill pinion gears and bearings and for all extra-heavy gears subjected to overload, reversal, and shock. This grade can be pumped in cold weather through steam-jacketed pipes and pumps. (Maurice Reswick, Chief Engr., Pennsylvania Lubricating Co., Pittsburgh, Pa., in *The Iron Age*, vol. 128, no. 13, Sept. 24, 1931, pp. 816–819, 4 figs., *dp*)



- NEUTRAL - - FULL SPEED FOR'D - - FULL SPEED REVERSE -

Fig. 4 Diagram of Diskon Variable-Speed Friction Gear

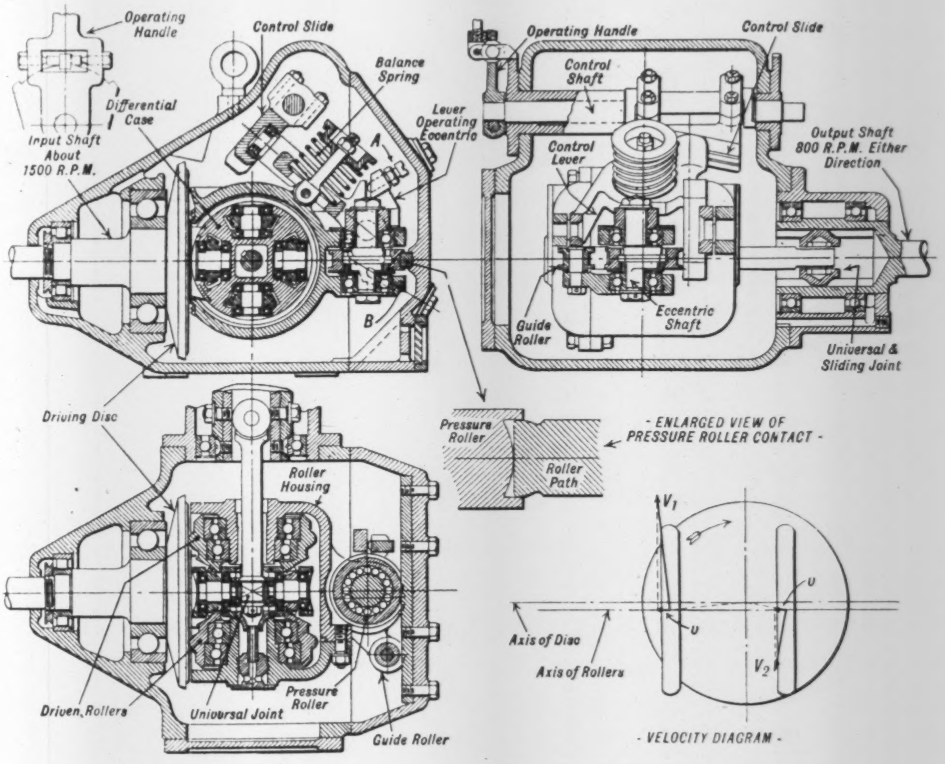

Operating Handle
Control Slide
Balance Spring
Differential Case
Input Shaft About 1500 R.P.M.
Lever Operating Eccentric
A
B
Operating Handle
Control Slide
Control Shaft
Control Lever
Output Shaft 800 R.P.M. Either Direction
Guide Roller
Eccentric Shaft
Universal & Sliding Joint
Driving Disc
Roller Housing
Pressure Roller
Roller Path
- ENLARGED VIEW OF PRESSURE ROLLER CONTACT -
V_1
V_2
v
v
Axis of Disc
Axis of Rollers
- VELOCITY DIAGRAM -
Driven Rollers
Universal Joint
Pressure Roller
Guide Roller

Fig. 5 Sections and Velocity Diagram of 5-B.Hp. Reversible Diskon Gear

MACHINE PARTS (See also Corrosion: Valve Corrosion, Design, and Lubrication)

The Diskon Variable-Speed Friction Gear

THE present gear differs from its numerous predecessors, first, in respect to the degree of hardness and elasticity of the disk and roller surfaces which has been rendered possible by the new alloy steels and improved hardening methods; secondly, in the employment of ball and roller bearings in all important wearing parts; and thirdly, by the use of a mechanical method for changing the point of contact of the roller with the disk and varying automatically the intensity of pressure between the surfaces according to the load the gear is desired to transmit. It is claimed that a further new feature is the use of a differential-gearwheel arrangement between the two friction rollers which avoids the necessity of carrying the driven friction roller across the center of the disk in order to obtain at the output shaft any desired speed in either the forward or reverse direction, thereby providing when required a zero position without the use of a clutch. The gear has been constructed under the patents of Dr. Hele-Shaw and T. E. Beacham.

The original article included a photograph of a 4-hp. unit intended to illustrate the small degree of surface contact which is necessary in order to transmit several horsepower.

From Figs. 4 and 5 it appears that a hardened steel disk on the input shaft drives two steel rollers which are maintained in contact with it by a force applied through a pressure roller. The position of this roller is so fixed that it is equidistant from the two driven rollers and thereby applies an equal pressure on each of them. The driven rollers are mounted on projections of the roller housing, and on the inner side of each there is formed a beveled gear which meshes with four pinions running on ball bearings which are carried in a cage, the complete assembly forming a differential gear. The cage is attached to the output shaft by means of a cardan shaft having a universal joint at its inner end and a universal and sliding joint at its outer end. The driven rollers are mounted on heavy ball races, and the whole of the mechanism runs in an oil bath. The roller housing itself is machined in such a manner that either right- or left-hand-driven shafts can be obtained. In Figs. 4 and 5 the gear is shown in the neutral position, in which the disk drives the two rollers in opposite directions at equal speeds, under which conditions the differential cage and the output shaft remain stationary, the operating lever being in the neutral slot at the center.

Let us now consider the diagrammatic drawings reproduced in

Fig. 4. In the full-speed-forward and the reverse positions it will be noted that the left- or right-hand roller, respectively, is revolving at the outer edge of the disk, and is therefore turning at its maximum speed. The inner roller, however, being on the opposite side of the center of the outer roller and nearer the center of the disk, turns in the opposite direction at a slower speed. The speed of the driven shaft, therefore, is that of the differential cage corresponding to the difference of the relative speeds of the two rollers.

The control of the positions of the rollers on the driving disk is obtained by moving the operating handle shown in Fig. 5. This raises or lowers the control slide shown to the right of Fig. 5, engaging with a small roller attached to the control lever. A movement of the operating lever lifts or depresses the main roller housing, and when this housing is lowered so that the axis of the rollers falls below that of the disk as shown in the velocity diagram reproduced to the right of Fig. 5, the velocity at the point of line contact of each roller must for non-slip conditions be at right angles to the disk radius, and it is shown that under these conditions the two rollers move as one. Further details are given in the original article, which also describes the manner in which the contact pressure is proportioned according to the load on the output shaft. (*The Engineer*, vol. 152, no. 3947, Sept. 4, 1931, pp. 250–251, 4 figs.; also *Engineering*, vol. 132, no. 3425, Sept. 4, 1931, pp. 282–283, 8 figs., *d*)

POWER-PLANT ENGINEERING (See also Internal-Combustion Engineering: Two-Cycle Possibilities for Portable Diesel Engines)

Dust Elimination From Chimney Gases

THIS article deals particularly with the products of Davidson & Co., Ltd., Belfast. The basic principle of the Davidson collector is the use of a large horizontal casing of volute shape through which the combustion gases pass around to the chimney, so that the dust particles are continuously forced outward by centrifugal force and downward by gravity, the dust-free gases passing out at the top while the separate dust is taken off from the bottom by a collector chamber forming the lower part of a high conical portion connecting to the hopper-shaped bottom of the main casing.

The Belfast company has just been awarded a contract for the new Dunstan B power station. Here the boilers are arranged in three groups of four, each supplying one turbo-alternator, and the contract consists of 48 electric-driven Sirocco fans, being induced- and forced-draft units for each of the twelve boilers, and 72 Davidson dust collectors. The fans will be driven by direct-coupled, totally enclosed motors of the squirrel-cage single-speed type, with provision for the inclusion of variable-speed hydraulic couplings so that the fan speeds can be varied immediately within a wide range according to the steam demand, with the motors running at fixed speeds. Also the motors can be thrown directly on to the electric supply under practically no-load conditions, as the load is applied gradually by increasing the speeds of the fan shafts after the motors are running at full speed, while the control gear is of simple and robust construction.

Further, Arca regulators will be included to control automatically through the hydraulic couplings the draft in the furnaces. Also the twelve Davidson collectors are to be arranged in groups of six collectors in parallel for each of the twelve boilers. The same arrangement is used at the new Iron Bridge power station now being erected near Shrewsbury, which is found to give even more efficient results than the use of several larger-diameter units, well over 90 per cent of the total dust being removed. In this last instance the collectors are to be placed between the boilers and the induced-draft fans to operate under suction—a new development—so as to separate all the erosive dust and grit before reaching the fans, which will operate against very high resistances, up to $12^{3}/_{4}$ in. w.g., the corresponding duty of the forced-draft fans being $10^{1}/_{2}$ in. w.g. pressure. Also the dust collectors are to have large airtight dust receivers to allow the storage, before emptying by special ejector equipment, of the material separated during 12 hr. when running continuously under maximum-load conditions.

An instructive aspect of this work of separating large quantities of dust from chimney gases, often amounting to some hundreds of tons a week, concerns the extremely small size of many of the particles. Also it has always been thought that the dust from chimneys serving mechanical-stoker-fired steam boilers is very coarse, while the dust due to pulverized firing is of necessity extremely fine. One of the results, however, of the investigations carried out in the Davidson experimental departments at Belfast is to show there is not very much difference in this respect. Regarding this, three figures in the original article may be referred to as a means of appreciating the particle sizes involved, since these are microphotographs of dust collected from various types of boiler-furnace systems by this make of separator.

The dust collected from boilers fired by mechanical stokers consists of particles less than 0.050 mm. in diameter. That collected from a pulverized-fuel-fired boiler at the Nechells power station, Birmingham, indicates that the portion of dust that floats on the water surface is less than 60μ in diameter. (*Mechanical World and Engineering Record*, vol. 90, no. 2323, July 10, 1931, pp. 30–32, 3 figs., *d*)

Lakeside—A Decade of Progress

THE Lakeside station installed in 1920 was the first all-pulverized-fuel plant and was also a pioneer in the use of high pressures and radiant superheaters. Of the minor developments the use of flue gas for mill drying and the location of the exciter fan on the inlet side of the pulverizing mill where it handles little coal dust, are improvements to which Lakeside contributed.

Among the operating results of Lakeside the following may be mentioned: Not less than 90 per cent high-pressure-boiler availability; a fluffy deposit and no slag in the ashpits; control of uniform superheat and reheat from full to quarter-load without complicated equipment; one boiler unit per high-pressure turbine; four hours pulverized-coal supply in case of mill outage, all for $80 per kw. installed, exclusive of step-up stations. A curve in the original article shows the growth of the size of boilers as reflected by the progress of the Milwaukee Electric Railway and Light Company. From this it would appear that boiler outputs have doubled every four years since 1910, and if continued at the same rate would bring by 1940 boilers of 200,000 kw. capacity. This would mean about 1,600,000 lb. of steam per hour, a figure well within the bounds of probability if load conditions can be increased to the point where units of this size can be used to advantage. On the other hand, as pressure increases, the water content of the boiler drums tends to decrease because of added cost.

Furnace volumes have increased slightly to expose sufficient radiant heating surface for moderate furnace temperatures, and the air-cooled refractory furnace walls of 1920 have given place to steam-cooled side walls, with the remaining walls, top and bottom, water cooled. This increase in furnace size has caused a decrease in the unit heat release, but increased preheat in the combustion air has resulted in approximately the same mean furnace temperatures in spite of the fact that in the new boilers 60 per cent of the total heat released by the coal is absorbed before the gases enter the boiler.

As regards performance, the heat rate has continuously dropped from 21,000 B.t.u. per net kw-hr. in 1921 to about 13,500 B.t.u. now.

The remainder of the article gives a history of the Lakeside station, which cannot be abstracted here because of lack of space. (*Power Plant Engineering*, vol. 35, no. 16, Aug. 15, 1931, pp. 830–837, 12 figs., *dh*)

The Single-Pass Boiler

NEW straight-tube single boilers with no economizer, air preheater, or induced-draft fan have been installed in the Duluth steam-electric station of the Minnesota Power and Light Co. and in the Boncar (W. Va.) plant of the West Virginia Hydro-Electric Company. In each case the boiler is 40 tubes high, which is sufficient to eliminate the use of either an economizer or air preheater, leaving the efficiency of the unit higher than that obtained with the conventional 3-pass boiler. The draft loss is sufficiently low so that it is not necessary to provide induced-draft fans. The actual height of the boiler itself is approximately 13 ft. greater than that of a 14-row-high 3-pass boiler.

At Duluth the unit is designed for a continuous load of 300,000 lb. per hr. and a 4-hr. peak load of 325,000 lb. of steam per hr., when burning Pittsburgh and Allegheny coals. The operating pressure is 415 lb. per sq. in., with a total steam temperature of 760 deg. fahr. This boiler contains 36,550 sq. ft. of heating surface, arranged in 38 sections wide, 40 rows high, and made up of 4-in. tubes 21 ft. long. This tube surface is divided into three definite banks or decks. The lower deck is made up of four full rows of tubes. The superheater, which is made up of 2-in. plain tubes, arranged 74 rows wide and 11 rows high, contains 8300 sq. ft. of gas-touched surface. This superheater is located in the space directly above the lower deck of the boiler. Three rows of horizontal circulators serve to connect the uptake headers to the boiler drum.

At Boncar, the unit installed is similar in design to the one in Duluth, but is only 33 sections wide with 31,885 sq. ft. of heating surface. The corresponding furnace width is 19 ft. 6 in. instead of 21 ft. 5 in. as at Duluth. The furnace is fully water cooled and contains 4200 sq. ft. of direct radiant-heat-absorbing surface. The maximum capacity of the unit is 325,000 lb. of steam per hr. and the operating pressure is 425 lb., with a total steam temperature of 750 deg. fahr.

The question is how an installation of this type can be justified in competition with a conventional 3-pass boiler equipped with an air preheater. The point is, however, that the units serve as stand-by to water power, and the yearly load factor may vary from 2 per cent to 15 per cent or more. The same units when operating will carry a constant load, the variations and peak loads being taken by the water power. An analysis of the performance of the single-pass boiler as compared with a suitable 3-pass boiler operating under the same conditions is made in the original article. The conclusion to which the author comes is that decision in favor of the single-pass boiler is based on the difference in operation and maintenance costs as well as on the saving in building volume. Units of this type are of relatively simple construction, because of the minimum amount of auxiliary equipment; the relative building volumes are small because of their simplicity; they have an extremely high availability factor; and because, while with its larger superheater the single-pass boiler is considerably higher in cost than the 3-pass boiler with its superheater, this difference is offset by the elimination of the cost of the air preheater and induced-draft fan, making the total first cost the same in the two cases. From an operating point of view, the single-pass unit is best for low-load factors.

Various analyses indicate that the single-pass boiler is particularly suited for low-load-factor units. The sizes most easily justified lie in the range from 200,000 to 400,000 lb. per hr. capacity. At capacities below 200,000 lb. per hr. the design is not economical, because of the high ratio of the drum and leader costs to tube-surface cost. Above 400,000 lb. per hr. the size of the unit is limited by the length that it is possible to manufacture the drums, and also by the amount of steam that can safely be generated by each section in the boiler. Of course, fuel costs also play an important part in the selection of these units. Relatively low-cost fuels usually indicate that it is desirable to investigate the possibility of installing units of this type. Because it is difficult to secure sufficient grate area for equivalent capacity, the unit is not particularly well suited to stoker firing, but such fuels as pulverized coal, gas, and oil are most ideally suited to its requirements.

In conclusion, it may be pointed out that actual installations and their operation indicate that all of the foregoing claims for the single-pass unit have been met. In fact, the performances of these units have exceeded the guarantee figures by comfortable margins. (Otto deLorenzi, Combustion Engineering Corp., New York, in *Power Plant Engineering*, vol. 35, no. 16, Aug. 15, 1931, pp. 837–839, 2 figs., *dc*)

PUMPS

A "Swimming" Pump

A NOVEL pump under the name of "swimming" pump was shown at the National Agricultural Exhibition held at Hanover, Germany, this summer. An electric motor with a vertical spindle was mounted in a cylindrical sheet-metal vessel of sufficient volume to float the motor and the centrifugal pump placed outside below the motor. This arrangement has the advantage that it is easily transportable and requires no fixing, as it has merely to be dropped into a pool of water and is ready to work as soon as the flexible cable is connected up. Further, the pump is not only always submerged to a sufficient depth, but as the depth does not vary, it works with a minimum lift and with a uniformly high efficiency. (R. Borlase Matthews, in *Engineering*, vol. 132, no. 3421, Aug. 7, 1931, pp. 155–156, illustrated, *d*. The particular device here described is shown on p. 156.)

SPECIAL PROCESSES

The Tarpon Metallization Process

IN THIS process the piece to be treated is first of all thoroughly cleaned, as, for example, by sand blasting. It is then covered, for example, by a spray gun with the metallization fluid which is made up of a mixture of heat-resisting varnish with an extreme finely subdivided metal powder, for example, aluminum powder. The layer so deposited is then heated by a torch, which is said to initiate processes of welding and transformation, with the result that a molten layer is created which penetrates into the smallest irregularities of the metal surface, unites thoroughly with the base metal, and produces a closely adhering protective layer of great hardness. It is claimed that the layer of protecting material thus produced is of close structure and impervious to water. It is claimed that so great is the adhering power of the layer that "tarponized" steel sheets have been subjected to rolling and stretching without producing pulling of the protecting material. The layer is said to be so hard that it can resist vigorous mechanical handling such as blows and rubbing. The operation of producing the protective layer is said to be very rapid as the spray gun is capable of covering from 10 to 12 sq. m. (107 to 140 sq. ft.) per hr. The time of drying the layer is also, of course, very short, and the material does not take up any water even when the operation is carried out in damp air. There is no possibility of saponification of the protective layer such as happens in paints and varnishes containing oil.

The hot-air torch used in this case is said to be suitable for a good many other operations. The temperature of the air under pressure may vary within wide limits up to, say, 700 to 800 deg. cent. (1292 to 1472 deg. fahr.). Georg Kutscher in *Verkehrstechnik*, no. 6, Feb. 6, 1931, pp. 82–83, 1 fig., *d*)

THERMODYNAMICS

Heat Transfer and Pressure Drop in Packed Tubes

THIS is a symposium consisting of three papers. In the first ("Heat Transfer in Packed Tubes"), Allan P. Colburn, of the Experimental Station, E. I. du Pont de Nemours & Co., Wilmington, Del., deals with the coefficients of heat transfer to air flowing through a tube filled with granular materials, such as a catalyst. The experimental apparatus and procedure are discussed in the original article, from which it would appear that these coefficients are about eight times as high as would be expected for the same gas rate through the empty tube. The coefficients have been found to vary with the mass velocity of the gas raised to the 0.83 power and with a function of the ratio of particle diameter to condenser diameter given by curves in the original paper. Typical data on the temperature gradient through the packing are shown by two groups of curves. The effect of radiation from the wall of the tube to the solids has been found to be very small. Some literature on the subject is cited at the end of the paper.

The next paper, by Thos. H. Chilton and Allan P. Colburn, both of the same organization, dealt with "Pressure Drop in Packed Tubes." This reports an investigation of the resistance of broken solids to fluid flow. The authors consider the flow of fluid through a bed of particles as flow through parallel conduits of irregular cross-section. The resistance to flow under isothermal conditions will then be made up mainly of the frictional resistance at the particle surfaces and the loss in head due to expansion and contraction. An exact determination of these resistances would be very difficult, but the order of magnitude of each may be estimated from the laws of flow through pipes, and is of interest in helping to understand processes such as absorption and heat transfer in packed towers which depend on the dynamic condition of the fluids.

The authors derive an equation for the pressure drop for certain conditions (Equation 19 of the original paper), as well as a theoretical relationship for the frictional resistance through broken solids for viscous flow and for turbulent flow. This latter was made possible by the fact that the effects of velocity, density, length, viscosity, and diameter are practically the same in the relationships for frictional resistance and for expansion and contraction losses in the turbulent and also in the viscous regions.

In the third paper, on "Relationship Between Heat Transfer and Pressure Drop," Allan P. Colburn and W. Julian King (the latter of the Engineering General Department, General Electric Co., Schenectady, N. Y.) find that for turbulent flow of gases in empty tubes, heat-transfer coefficients vary with the 0.44 power of pressure drop as the velocity is increased. The introduction of baffles or packing into a tube increases the heat transfer to a somewhat less extent than the 0.44 power of pressure drop, but in a regular manner. From the curves given in the original paper it seems possible that the heat-transfer coefficient for almost every type of baffle or packing can be estimated if the pressure drop is determined. Some literature is cited. (*Industrial and Engineering Chemistry*, vol. 23, no. 8, Aug., 1931, pp. 910–923, *e*)

VARIA

Relation Between an Engineering Education and Income

THE article here abstracted is based on a study of the salaries of the engineering graduates of the Carnegie Institute of Technology, which are also compared with the salaries of graduates from other engineering institutions. The information was secured by a card which was sent to all alumni. Incidentally, each graduate was asked to state his approximate salary as well as the wage he would consider in changing his position. For methods of comparison the median wage had to be determined. To do this the median term was located by dividing the number of terms plus one by two. The median value is approximated by interpolating within the group containing the median term on the assumption of an equal distribution within the class. Inspection of the tables in the article shows that the highest salaries were obtained by the graduates of the metallurgical and commercial engineering departments, and the lowest by those of the mining and civil departments. The figures obtained are compared with the results of a similar study in 1924 made by the Society for the Promotion of Engineering Education. From this it would appear that the median yearly salary of Carnegie men for the first ten years out of school was higher than that of other engineering-school graduates.

The relation between an engineering education and income has been forcibly demonstrated as far as the Carnegie Institute of Technology graduates are concerned by the fact that only 3 or 4 per cent of the alumni are unemployed at present (June, 1931). Estimates of the percentages of the total number of unemployed workers in the United States vary from 10 to 25 per cent.

In this study no attempt was made to ascertain to what extent Carnegie graduates were engaged in engineering work, previous studies having disclosed the fact that about 80 per cent were engaged in the engineering field or in closely allied forms of work. While the money return is not the only one considered by the professional man, it is, however, the most easily measured and therefore forms the readiest method of comparison between those engaged in the professions or in any of the vocations. (John D. Beatty, Secretary of the Bureau of Recommendations, Carnegie Institute of Technology, in *Industrial and Engineering Chemistry*, vol. 23, no. 9, Sept., 1931, pp. 1070–1073, 6 figs. *g*)

WELDING

A 732-Mile Pipe Line

THIS article describes the welding of the pipe line recently completed from Perryman, Okla., to various points in Ohio and Pennsylvania. The pipe is made of National seamless tubing and lap-welded standard pipe equipped with double-bell and chill-band joints. Each pipe length is belled at both ends, and the ends are beveled so that in arc welding the joint the weld penetrates through to the chilled band. The welds were made by what is claimed to be a new process utilizing the shielded arc. No details of the process are given, except that it is stated that the welds were made in an atmosphere free of oxygen and nitrogen. In a number of cases, it is stated, operators completed more than 50 welds in a 9-hr. day. A section of the line was tested and no leaks were discovered. The method of lining up the pipe and completing the firing-line weld is described and illustrated in the original article. When completed this pipe line will be served by fourteen pumping stations, each equipped with oil-engine-driven reciprocating pumps. The line will have a working pressure of approximately 700 lb. per sq. in. and a capacity of 35,000 to 40,000 bbl. per day. (A. F. Davis, Vice-Pres., Lincoln Electric Company, in *Journal of the American Welding Society*, vol. 10, no. 5, May, 1931, pp. 14–15, 5 figs., *d*)

Instruments and Apparatus

Preliminary Draft of Part 18—Humidity Determinations

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 18—Humidity Determinations. The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and W. A. Sloan.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam,[4] (12) Time Measurements, (13) Speed Measurements,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations,[6] (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[8]

Complete copies of the draft, which is published here in abstract, may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

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SYMBOLS

c_{p1} = specific heat of air at constant pressure
c_{p2} = specific heat of water vapor at constant pressure
d_{v1} = density of saturated water vapor at the temperature of the atmosphere
d_{v2} = density of saturated water vapor at the dewpoint
h_a = heat content of one pound of dry air at temperature t_1
h_{fg} = latent heat of dry saturated water vapor (B.t.u. per lb. of dry saturated vapor)
h_g = heat content of dry saturated vapor
L = latent heat of vaporization of water vapor at pressure p_{v2} or temperature t_1
p_a = partial pressure of air in any atmosphere
p_B = barometric pressure
p_1 = total pressure of any mixture of gases
p_2 = total pressure in aspirator or meter of chemical hygrometer
p_v = partial pressure of saturated water vapor, at wet-bulb temperature (temperature of adiabatic saturation) in psychrometer
p_{v1} = partial pressure of saturated water vapor at the temperature of the atmosphere
p_{v2} = partial pressure of saturated water vapor at the dewpoint
p_{v3} = partial pressure of saturated water vapor in the meter or aspirator of a chemical hygrometer (temperature, t_4)
R = relative humidity
t_1 = temperature of the air, deg. fahr. (dry-bulb temperature)
t_2 = wet-bulb temperature, deg. fahr. (temperature of adiabatic saturation)
t_3 = temperature at dewpoint, deg. fahr.
t_4 = temperature of aspirator or meter of chemical hygrometer, deg. fahr.
v_1 = specific volume of dry saturated steam at pressure p_{v2}
V_1 = volume of dry air at atmospheric temperature t_1 and pressure p_B, which weighs the same as the dry air in the aspirator, having volume V_2, temperature t_3, and pressure p_2 (saturated with water vapor)
V_2 = volume of aspirator or meter reading, cu. ft.
W = weight of dry saturated steam which occupies the volume of one pound of dry air at temperature t_1
W_1 = weight of water vapor mixed with one pound of dry air at dry-bulb temperature, lb. (specific humidity)
W_2 = weight of saturated water vapor mixed with one pound of dry air at wet-bulb temperature, lb.
W_3 = density of saturated vapor at temperature t_1, lb. per cu. ft.
W_4 = increase in weight of absorption material in chemical hygrometer, lb.

GENERAL

1 With the increase in the understanding of the effects and utilization of moisture in the air and other gases, the accurate measurement of the moisture, both specific and relative, has come to be a matter of great importance. Means for quickly determining the moisture content of any atmosphere had to be devised before regulating apparatus for moisture control could be developed.

2 There are two different concepts of relative humidity. It is defined either as the ratio of the actual vapor pressure to the saturation pressure, or as the ratio of the actual weight per unit volume to the weight per unit volume at saturation. The former definition has been adopted and is used throughout this section of "Instruments and Apparatus." The ratios resulting from these two definitions are virtually equal.

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[1] See pamphlet published in June, 1928.

[2] Chapter 1 of Part 2, on "Barometers," was published in pamphlet form in June, 1929. Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in pamphlet form in June, 1929.

[3] Part 3, Chapter 1, "General," Chapter 5 on "Pyrometric Cones," Chapter 6 on "Liquid-in-Glass Thermometers," and Chapter 7 on "Bourdon Tube Thermometers," were published in pamphlet form in March, 1931.

[4] See pamphlet published in January, 1931.

[5] See pamphlet published in December, 1930.

[6] See pamphlet published in April, 1931.

[7] See pamphlet published in January, 1931.

[8] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

3 This section of "Instruments and Apparatus" treats of four general types of instruments available for the measurement of the water-vapor content of gases. The first of these is the dewpoint hygrometer,[9] which finds its greatest application in physical and chemical laboratories. While this instrument is of comparatively high accuracy, its lack of simplicity in operation does not commend it for test work. The second type, the psychrometer, in its various forms finds extensive application in test work. This instrument has the advantage of rather high accuracy and simple application. In its modified form it is used in humidity control both for the humidifying and the dehumidifying of atmospheres. This instrument may be used when it is desired to obtain results quickly. It is of sturdy construction and does not require frequent adjustment. The third type is the absorption hygrometer the sensitive member of which is usually made of human hair. It finds wide application in Weather Bureau work, although the sling psychrometer is the primary instrument used. It is delicate and needs too frequent calibration and adjustment to find general application in mechanical-engineering work, except in autographic apparatus, for which it is widely used on account of its simplicity and convenience in making permanent records. The fourth type, the chemical hygrometer, is an instrument of relatively high precision, because the results depend largely upon a weight determination and the reading of a volume. This instrument, however, gives the average of moisture conditions over a considerable period of time. For measuring average moisture in a pipe carrying gas or air over a considerable period of time this instrument is very satisfactory, but for test work in measuring or controlling humidity, results can be obtained more rapidly with the psychrometer.

4 In order to thoroughly understand the use of apparatus for determining humidity, the following fundamental definitions should be clearly understood:

Humidity is the water vapor in any atmosphere. The atmosphere may be a mixture of water vapor and air, or water vapor and any other gas or mixture of gases.

Partial Pressure. In any mixture of perfect gases, each constituent gas exerts a pressure which depends upon the total pressure and is independent of the other gases present. The pressure of each gas in the mixture is known as its partial pressure. The total pressure exerted by the gas mixture equals the sum of these partial pressures.

Saturation is the state of water vapor in which its pressure is a maximum for its temperature. A gas mixture containing water vapor is commonly said to be saturated when the partial pressure of the water vapor in the mixture corresponds to that of saturated steam as shown in a steam table or a chart, but this is a loose use of language, and should be discouraged in technical discussion. It is the vapor that is saturated, not the mixture.

Dewpoint is the temperature at which the water vapor in any mixture of a gas and water vapor becomes saturated. This is found by cooling the mixture at constant pressure until saturation occurs. The apparatus used to determine the dewpoint will be described under "Dewpoint Hygrometer." (See Par. 5.)

Specific or Absolute Humidity is the weight of vapor per unit weight of air.

Relative Humidity is, by definition, the ratio of the actual partial pressure of the vapor in a mixture to the pressure of saturated vapor at the same (dry-bulb) temperature. This ratio is equal to the ratio of the actual vapor density in the mixture to the density of saturated vapor at the same (dry-bulb) temperature.

A numerical example will illustrate the close equivalence of these two ratios. The following conditions will be assumed:

Air temperature	75 deg. fahr.
Dewpoint	55 deg. fahr.
Barometric pressure	normal for sea level

The following characteristics of water vapor are taken from Keenan's steam tables.

Temperature, deg. fahr.	Saturation pressure, lb. per sq. in.	Density at saturation, lb. per cu. ft.
75	0.4295	0.00135
55	0.2140	0.00698

The water vapor in the atmosphere when the relative humidity is less than 100 per cent, obeys the laws of Charles and Gay-Lussac.

The absolute pressure, temperature, and density are interconnected. The pressure and specific volume are proportional to the absolute temperature. The density is inversely proportional to the absolute temperature.

The partial pressures of water vapor at air temperature and at the dewpoint are identical. The ratio of the densities of superheated water vapor at air temperature and of dry saturated water vapor at the dewpoint is the inverse of the ratio of the absolute temperatures.

By the ratio of densities

$$\begin{aligned} R &= 100 \times \frac{460 + 55}{460 + 75} \times \frac{0.00698}{0.00135} \\ &= 49.8+ \text{ per cent.} \end{aligned}$$

By the ratio of pressures

$$\begin{aligned} R &= 100 \times \frac{0.2140}{0.4295} \\ &= 49.8+ \text{ per cent} \end{aligned}$$

AVAILABLE TYPES OF INSTRUMENTS

5 *Dewpoint Hygrometer.* This type of instrument, consisting of a highly polished silver or copper surface which is in contact with the atmosphere under test, is cooled by the evaporation of a volatile liquid inside the instrument. The evaporation of the liquid is accelerated by blowing air through it. As soon as the temperature of the surface reaches that of saturation of the vapor in the atmosphere under test, a film of condensed vapor will appear. A thermometer is provided which measures the temperature of the surface by measuring the temperature of the volatile liquid in contact with it. The temperature at which this clouding appears is the dewpoint.

6 The absolute pressure of saturated vapor at the dewpoint divided by the absolute pressure of saturated vapor at the temperature of the atmosphere equals the relative humidity, or

$$\frac{R}{100} = \frac{p_{v2}}{p_{v1}}$$

7 The density of saturated vapor at the dewpoint, corrected for absolute temperature divided by the density of saturated vapor at the temperature of the atmosphere under test is approximately the relative humidity, or

$$\frac{R}{100} = \frac{d_{v2}\left(\dfrac{T_2}{T_1}\right)}{d_{v1}} = \frac{d_{v2}T_2}{d_{v1}T_1}$$

The dewpoint hygrometer is applicable only for ordinary temperatures, say, up to 120 deg. fahr. It is not easily applicable to measurement of humidity other than that of the atmosphere. The accuracy obtainable with it depends upon the observer. (See Pars. 16–22, inclusive.)

8 *Wet- and Dry-Bulb Psychrometer.* This type of instrument consists of two similar thermometers so mounted that the bulb of each will be bathed with the atmosphere under test. The bulb of one thermometer is wrapped in a highly absorbent cloth which is kept wet with water, while the bulb of the other is left

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[9] **A hygrometer is any device used for measuring the degree of moisture in an atmosphere, or, literally, it is a moisture measurer. A psychrometer is a hygrometer made of two identical thermometers, one of which has a wet bulb, the other a dry bulb, or literally, it is a cooling measurer.**

bare and dry. Both bulbs should be shielded from direct radiation from heated sources; that is, if the instrument is being used out of doors on a sunny day it should be used in the shade rather than in the direct sunlight. Wet- and dry-bulb psychrometers are made in unventilated (old form), ventilated, and sling forms.

9 The ventilated form of psychrometer is so constructed that the atmosphere under test is drawn by a fan over the bulbs of the thermometers. The thermometers may be of the Bourdon tube type with a recording device for making a record of the wet- and dry-bulb temperatures. In operation the cloth-covered bulb of the psychrometer is wet with pure water at or near the normal temperature of water exposed to the atmosphere. The recording portable psychrometer is provided with a continuous supply of water from a reservoir for the cloth-covered or wet-bulb thermometer. (See Pars. 23–42, inclusive.)

10 In the sling form of psychrometer two glass thermometers are mounted on a strip of metal to one end of which a handle is fastened so that the metal strip can be revolved rapidly by hand in the atmosphere whose humidity is being determined.

11 A spray may be used, instead of a saturated wick, for attaining the wet-bulb temperature. This form is particularly well adapted for stationary equipment used for continuously recording or controlling the humidity, as there is no wick requiring periodic renewal.

12 *Absorption Type of Hygrometer.* Many organic substances change their dimensions when exposed to moisture. Rope and catgut strings contract, whereas hair elongates with increase of moisture absorbed from the air. Human hair is one of the most sensitive substances. The hair hygrometer contains an elongating and contracting element made of hair. The change in length is transmitted through a simple mechanism to an indicating or recording needle.

13 There is no exact theory explaining the working of this instrument. Each one must be calibrated by reference to some standard instrument, and must be frequently calibrated thereafter because its calibration cannot be depended upon with change of temperature and aging of the hair. This instrument finds only limited application in testing work. (See Par. 43.)

14 *Chemical Type of Hygrometer.* The quantity of water vapor in any atmosphere may be ascertained by the direct determination of the weight of water extracted from a measured volume of that atmosphere passing through suitable drying agents such as phosphorus pentoxide, freshly fused calcium chloride, or fragments of some neutral solid saturated with concentrated sulphuric acid. A drying tube next to the aspirator is desirable for the purpose of preventing water vapor from the aspirator getting into the weighed drying tubes, of which there are usually two.

15 This method of determining humidity although possessing the advantage of depending ultimately on a weighing, which is one of the most accurate processes in physical investigation, is exceedingly tedious in practice. It is not suited to indicate rapid changes in hygrometric state, but measures the mean value of humidity during the interval of test. (See Pars. 44–50, inclusive.)

DETAIL DESCRIPTION AND METHODS OF APPLICATION

DEWPOINT HYGROMETERS

16 *Regnault's Hygrometer.* A form of dewpoint hygrometer is that devised by Regnault,[10] and employed in his studies in hygrometry.

The essential part of the apparatus is a glass tube *D* (Fig. 1[11]) open at both ends, to the lower end of which a thin polished silver thimble is attached. This thimble contains ether, alcohol, or some other volatile liquid. The upper end of the tube is closed airtight by a cork, through which passes the stem of a thermometer *T*, and an open piece of bent glass tube *A*, the lower end of which penetrates nearly to the bottom of the liquid contained in the thimble. A tubulure in the side of this tube fits into a vertical brass tube which forms the support of the apparatus. The lower end of this brass tube is connected with an aspirator, by means of which a current of air can be drawn through the system, entering by the bent glass tube *A*, and bubbling through the ether. By this means evaporation of the liquid is produced with consequent cooling, and dew is deposited on the surface of the polished silver. In order to facilitate the observation of this, a second tube, *E*, with a similar thimble is supported beside that just described. This tube is empty, and merely carries a thermometer *t* which gives the temperature of the air. Thus by comparison of the two silver thimbles the temperature at which the dew appears or disappears can be ascertained. The aspirator is placed at a convenient distance, and the apparatus is viewed through a telescope. The air around the apparatus is thus undisturbed by the breath and presence of the observer, and the flow of air through the aspirator can be so controlled that the temperature at which the dew appears will be almost exactly the same as that at which it disappears. If the aspirator is controlled with great care, the dew may be even made to appear and disappear without any observable change in the reading of the thermometer. The process of cooling by the bubbling of air through the ether is advantageous, for by this means the liquid is kept well stirred and at a uniform temperature throughout. This is the temperature registered by the thermometer, and it cannot differ sensibly from that of the surface on which the dew is deposited, since the thimble is thin and a good conductor. The other obvious advantages of the method are the absence of the observer from the neighborhood of the apparatus, and the delicacy with which the flow from the aspirator can be controlled.

17 This dewpoint hygrometer is not suited for use in the open air except in calm weather. When the air is still, the layer immediately in contact with the cooled metallic surface may, no doubt, be in thermal equilibrium with the latter, even though it is surrounded by layers of warmer air, since air is a bad conductor; but in a fresh breeze the constant renewal of the air prevents its attaining the dewpoint unless the instrument is cooled to a considerably lower temperature. On this account this hygrometer, when used in the open air, gives results which do not agree with those of the chemical hygrometer and two hygrometers of this same type are even difficult to check.

18 *Crova's Hygrometer.* Fig. 2*a*[11] gives a general view of the instrument, a section of which is shown in Fig. 2*b*; *efgh* is a tube of thin brass, nickel plated inside and carefully polished. The end *ef* is closed by a disk of ground glass which is illuminated by daylight or by a lamp, and which is viewed through a lens *gh* which closes the other end of the tube. The image of the window *ef*, seen by reflection in the polished sides of the tube, appears as an annular ring of light *e'eff'* of three times the diameter of *ef*.

19 Air can be slowly drawn through the brass tube by compressing and slowly releasing an india-rubber ball connected to tube *t*, and if the tube is cooled to the dewpoint, the deposition of dew is immediately indicated by the darkening of the reflected image of *ef*. In order to regulate the temperature of the tube, the latter is surrounded by a brass box *abcd* containing bisulphide of carbon, through which air can be blown from the mouth by means of a rubber tube fitted to the tubulure *T*, Fig. 2*a*. M. Crova prefers carbon bisulphide to ether, because it is more

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[10] Regnault, *Ann. de Chimie et de Physique*, 3rd ser., tome xv, p. 129, 1845.

[11] Not shown in this abstract.

readily obtained pure, and also because it does not boil in hot weather. Ordinary commercial ether contains water and alcohol, which are left behind when the ether evaporates. It is, however, possible to attain a lower temperature with ether than with carbon bisulphide. A thermometer graduated in fifths of a degree dips into the liquid, and is in contact with the brass tube. A blackened screen *EE* protects the eye from external light. *Ii'* is a rubber disk insulating the brass box from its stand, through which heat might otherwise be conducted.

20 The advantage of this hygrometer is that the whole of an enclosed volume of air is cooled to the temperature of the dewpoint, and that it is unaffected by drafts. By attaching a long tube to the opening *t*, the atmosphere tested can be drawn from a point out of reach of the influence of the observer or of contamination by the vapor of carbon bisulphide, or from a pipe or duct. It can be regulated so that the appearance and disappearance of dew are within 0.2 deg. fahr. of each other.

21 This type of hygrometer may be used over the whole field in which humidities are measured. The Regnault instrument must be installed where it will be free from direct radiation from the sun or other highly heated sources. The results are also discordant, if used in a strong breeze. The Crova hygrometer eliminates the need of both of these installation precautions. The Regnault apparatus must also be read with a telescope so that the instrument may be out of direct influence of the breath and radiated heat from the observer. The Crova instrument may take its atmosphere under test from any source since the atmosphere is conducted to the instrument through a tube.

22 Correction and calibration precautions are the same as apply to liquid-in-glass thermometers. (See Part 3, Chapter 6 of "Instruments and Apparatus.")

Correspondence

The Lorenzen Gas Turbine and Supercharger for Gasoline and Diesel Engines

To the Editor:

Referring to his paper published in the July, 1930, issue of Mechanical Engineering,[1] Dr. Lorenzen is to be congratulated on the very ingenious mechanical construction which he has developed. The general design and the methods of manufacture are exceedingly interesting. It is a remarkable achievement to have built a rotor with the many individual parts shown, which operates both as a gas-turbine wheel and a centrifugal-compressor impeller, and which will withstand the speed of 30,000 r.p.m. which Dr. Lorenzen mentions.

It would be desirable if Dr. Lorenzen would give some record of the gains secured in the actual operation of the supercharger when added to the engine. What was the power of the given engine without the supercharger, and what increase in power was obtained with it? What was the comparative fuel consumption in the two cases? Dr. Lorenzen also gives some data regarding a gas turbine operated as a direct prime mover, without any interposition of the reciprocating engine. Has he any data of actual operation of such an arrangement? If so, the thermal efficiency or fuel consumption would of course be interesting.

Büchi has operated exhaust-gas turbines with separate nozzle chambers and banks of nozzles for groups of cylinders. Were Dr. Lorenzen's actual exhaust-gas superchargers operated on this basis, or did he have a single nozzle box which received all of the exhaust gases with a single bank of nozzle sections?

It is to be noted that the two-wheel type of exhaust-gas turbine is in successful commercial operation in a great many cases as a supercharger for both aviation engines and Diesel engines. This two-wheel type has a turbine wheel which handles exhaust gases only, and an entirely separate impeller for the centrifugal compressor. Uncooled turbine wheels in such outfits are actually handling the exhaust-gas temperatures without any difficulty. It would be desirable if Dr. Lorenzen would explain the advantage secured by use of his single wheel, combining the turbine wheel and compressor impeller in one structure. Will it be cheaper than the two simple wheels? In view of the many exhaust-gas turbines actually operating without any cooling of the buckets by the air from the centrifugal compressor, what is to be gained by the complication necessary to give such cooling? There are also certain theoretical objections to this cooling, and it would be desirable if Dr. Lorenzen would give his actual experiences, which would tend to offset these objections. Two such theoretical objections may be mentioned. One is that the mechanical design of Dr. Lorenzen's double wheel, even though it is very ingenious, nevertheless gives certain high velocities and irregularities of flow, so that the mechanical efficiency of both turbine and compressor may be impaired. Such losses do not occur with two simple wheels, each designed for its own function. The other theoretical objection is that the thermodynamic efficiency of the turbine is impaired by loss of heat which passes to the air being compressed. Furthermore, the theoretical power for compression of the air is appreciably increased by heating it during compression. Does Dr. Lorenzen find that these theoretical losses are noticeable in his actual apparatus?

Sanford A. Moss.[2]

To the Editor:

Through some mistake Dr. Moss's discussion of my paper did not come to my notice until very recently. I am very glad to answer his questions, particularly as they come from one so eminent in the supercharger field.

For economy's sake most of my tests were made on automobile engines, although bench tests on aviation motors up to 600 hp. were also carried out. The increase in output depended to a great extent on the make of the engine. Engines with a compression ratio above 1:5.3 did not increase in output as much as engines with a lower compression ratio. The reason for this is that in engines with higher compression ratios the fuel was utilized better inside the cylinders, whereas with lower ratios the temperature of the exhaust was higher and therefore also the turbine performance, which showed itself in a higher supercharging. The increase varied from 20 up to 38 per cent, the average being about 30 per cent.

The fuel consumption with the supercharger in action increased but slightly, in spite of the considerable increase in output. The accompanying illustration of a supercharger in a motor car shows the arrangement by which, through a simple movement of a lever in the steering column, the supercharger can be put in and out of action, the jets in the carburetor remaining exactly the same. With the supercharger in action, about 10 m.p.h. higher speed is the result.

This good result is due to two things: The first is that by supercharging from 3 to 9 lb. per sq. in. above atmospheric pressure the suction stroke of the engine becomes a working stroke and saves energy. The second is that through the increased temperature of the combustion air a much better evaporation of the fuel takes place. This is shown by analyses of the exhaust gases, as follows:

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[1] "The Lorenzen Gas Turbine and Supercharger for Gasoline and Diesel Engines," by Christian Lorenzen. Mechanical Engineering, July, 1930, p. 665.

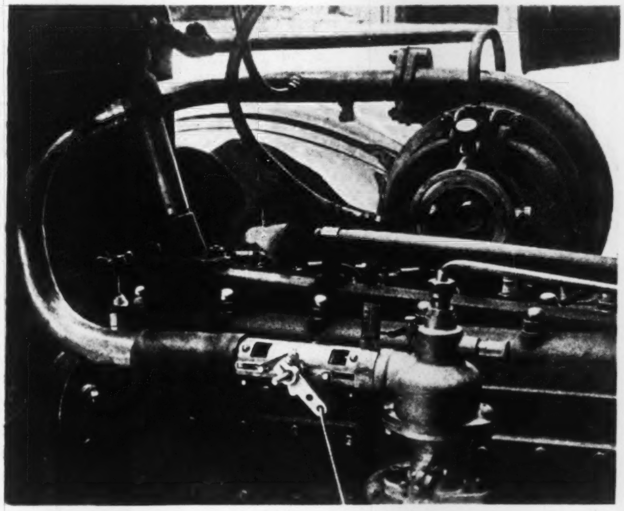
[2] M.E., Thomson Research Laboratory, General Electric Co., Lynn, Mass. Mem. A.S.M.E.

	CO_2	O_2	CO
At half load, per cent	14.0	0.5	0.0
At full load, per cent	14.2	0.6	0.0

The increased temperature of the air also heated the carburetor, which caused a slightly increased fuel supply. This is also desirable owing to the slight increase in weight of the air, in which the higher pressure more than counterbalances its expansion through heating.

The live-gas turbine illustrated in the paper could not be completed for lack of funds, consequently no actual data as to its economy are available.

The first exhaust-gas turbines constructed about sixteen years ago had a special pipe from each cylinder. Later the number of pipes was reduced to one or two, depending on the type of engine. If possible, two cylinders are not permitted to "overlap" in the exhaust stroke in the same nozzle box.



SUPERCHARGER IN MOTOR CAR

The reasons for the combination of turbine and compressor into one wheel are many, but the chief one is that of security. "Safety first" is a much-employed phrase, particularly in aviation, and the entire engineering world is well aware that the gas turbine cannot be developed for general use, because no materials available will withstand the high mechanical stresses involved at the temperature encountered. In the Diesel process with its high compression ratio the exhaust temperature is comparatively low. Therefore Büchi could find steel suitable for use at 540 deg. cent. (= 1000 deg. fahr.) when the circumferential speed was but slightly above 500 ft. per sec. But in gasoline operation, where the exhaust temperature is about 800 deg. cent. (= 1470 deg. fahr.) and the circumferential speed as high as 1000 ft. per sec., there is no material existing which will withstand such stresses without a cooling arrangement. When a cooling arrangement must be provided, then it is cheaper both thermodynamically and commercially to combine both wheels into one. The perfect internal cooling of rotor and buckets described in my paper, combined with the extreme lightness of the hollow buckets, permits a higher circumferential velocity to be safely employed than even in a steam turbine.

If no internal cooling is arranged for, then it must be done externally. In both cases the amount of energy required to bring about such cooling may be the same, but in the former this energy is, apart from the efficiency figure, stored up in the compressed air, whereas in the second case, with external cooling, such energy is lost. Another advantage of internal cooling is that such cooling takes place *continuously* as long as the turbine is running, whereas when external cooling is employed, no cooling can take place while the exhaust gases are passing the buckets, so that heating and cooling work in a way like alternating current.

No doubt the efficiency of a specially built impeller for the compressor wheel should be better than in the case of the combined wheel, but the difference is not as great as the ventilation losses caused by the second wheel. Therefore the combined wheel will obtain a higher circumferential speed with a given weight of exhaust gases, particularly as the latter strike the buckets throughout their circumference.

True, by heating the air through the cooling of the buckets, during its compression, a larger amount of energy is required to obtain the same pressure. But the energy saved because of the less ventilation work required in the single wheel can now be used to make good such losses. However, the efficiency of the turbine is not impaired by loss of heat in the exhaust gases; in fact, there should be a slight increase in efficiency, inasmuch as the given weight of exhaust gases has its full temperature and corresponding velocity when striking the buckets of the combined turbine and compressor wheel. In doing so they give off heat to the cooling air, with the result that its volume is decreased so that the velocity of the leaving gases is lower than when no cooling takes place. Such lower velocity of the leaving gases is of advantage to the impelling gases.

Internal cooling also makes it possible to enclose the turbine wheel in a proper casing, and the turbine, having a sufficiently large exhaust pipe, may also be built inside the body of the airplane and will then cause no obstruction thereto. Even with such a casing the weight is considerably less than with two wheels; for example, for a 450-hp. aviation motor the weight of the turbine compressor with casing is only 77 lb.

As said earlier, however, increased safety has been the principal reason for the construction of the combined turbine compressor.

CHRISTIAN LORENZEN.[3]

Strength of Welded Shelf-Angle Connections

TO THE EDITOR:

An abstract in the September issue of MECHANICAL ENGINEERING gave results of some tests made at the Bureau of Standards to determine the strength of welded connections of the seat-angle type for use in steel-frame buildings. Since the specimens failed in the weld it appears that a low grade of welding wire must have been used, and that more attention should be given to the use of a high-strength wire. The strength of welding wire will decrease 10,000 lb. in the welding operation, and many welds are made with wire having a tensile strength of but 55,000 to 60,000 lb. When one considers the reduction in strength due to the arc and further reductions due to the process followed, allowance for voids, pits, and occluded gases, the ultimate strength may be quite low. Questions that naturally arise are: Was the welding wire bare or coated? Was the welder using straight polarity? Was there sufficient heat, or was the operator welding too fast?

Among welding failures that have come to the writer's attention was one case where teeth broke out of a welded gear. The gear material was guaranteed to have a tensile strength of 70,000 lb. A cheap wire had been used in welding that cost 6 cents per pound and had a tensile strength of but 55,000 lb.

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[3] Engineer and Managing Director, Lorenzen G.m.b.H., Berlin, Germany.

This wire was used because it was cheap. If any one expects a wire of less tensile strength than the original material to carry the load, they are reasoning from a faulty standpoint.

Many appear to think there is something magical in the art of welding. There isn't. It calls for good engineering, commonsense, and good welding equipment. The company with which the writer is connected uses a coated wire of 92,000 lb. tensile strength. In the weld it will run about 70,000 lb., and it is found that the heavier the coating, the tougher and more ductile is the weld. One reason for this firm's success is the use of a steel reduced by the electric process. Its carbon content is uniform throughout, it is tough, strong, and ductile, and it costs 25 cents per pound. If it could be sold for 6 cents per pound there would be fewer failures in the welding industry. There should be a vigorous campaign to demand the use of a wire which has a tensile strength of at least 20,000 lb. more than the job to be welded.

ROYAL MATTICE.[4]

Standardization of Machining Finishes

TO THE EDITOR:

The proposals outlined in Mr. Deale's article[5] in the October issue of MECHANICAL ENGINEERING come at a very opportune time, inasmuch as the demand for the maintenance of the original tolerances in high-class machinery is increasing.

The purchasers of automobiles, domestic refrigerators, phonographs, sewing machines, and other domestic appliances of a mechanical nature, all of which are used in vast quantities, are expecting and insisting on a longer period of usage before the inevitable wear makes such appliances noisy or in other ways unsatisfactory for their original purposes. Even the introduction and quite general use of anti-friction bearings does not entirely eliminate the eventual unsatisfactory performance of the mechanisms involved, as these elements in turn are subject to wear.

Particularly is the foregoing thought exemplified in the modern automobile, many of which will continue to perform without perceptible evidence of wear resulting in noise after twenty thousand miles of usage.

While much has been done by competent lubrication engineers to eliminate the metal-to-metal contact between load-carrying elements, the true function of the lubricant has been shown to be impossible of attainment if the working surfaces are not properly prepared.

While the advent of the precision grinding machine probably represents the most forward step recorded during the past fifty years in the making of working surfaces with a reduced potential wear, the demands for quiet and efficient performance have grown to such an extent that there has arisen a very real commercial necessity for an engineering control of the processes of finishing and a means whereby the engineer can quickly and clearly convey his requirements to the personnel, whose function it is to actually manufacture the mechanical components.

Careful research coupled with practical experience, based on the operation of a great number of mechanisms in service, indicates that each one of the generally accepted machined surfaces or finishes of today has, under given load and lubrication conditions, a definite potential wear, and manufacturers have realized that it is entirely futile to specify extremely close tolerances on surfaces which possess this relatively high factor of potential wear. No better example can be quoted than the automobile piston pin, as this element, probably more than any other in the modern automobile, is stressed more highly in proportion to its area than any other of the load-carrying elements. Improperly finished pins may have as high a potential wear as 0.0005 in. on the diameter after, say, an eight-hour run in the engine, and it therefore follows that when manufacturing this pin it is a futile waste of money to specify a total tolerance of 0.0002 in.

It was with the thought in mind of drawing attention to this phase of manufacturing conditions, that the writer presented his paper entitled "A Survey of Surface Quality Standards and Tolerance Costs Based on 1929/30 Precision-Grinding Practice" at the A.S.M.E. Annual Meeting in December, 1930.

Already considerable experience has been gained in the control of the quality of grinding finishes along the lines of the scheme described in this paper, and sufficient evidence is forthcoming to indicate that it not only enables the engineer to control his tolerances, but in addition it makes for real economies in the cost of manufacture.

That this scheme of designating and controlling finishes should be extended to surfaces machined by other processes is only logical, and Mr. Deale's proposal to extend the application to drawings calling for turning, boring, milling, and planing operations is in line with sound economics from the points of view of both the engineer and the manufacturing superintendent.

Another important benefit will be made available to the mechanical-engineering industry by the establishment of national standards. Under present conditions the quality of surface to be produced by a newly installed machine tool is more often than not a matter of opinion. The limits of deviation from a nationally acceptable standard are not defined, and it is reasonable to assume that the misunderstandings which occasionally arise due to this factor alone, cost the industry a considerable amount of money.

The general acceptance of the fact that the cost of production increases or decreases precisely as the quality and accuracy of the surface produced, will help materially to a realization that the correct specification of surface standards is an economic necessity.

The manufacturing procedure now generally followed, as described by Mr. Deale, whereby the quality of vitally important surfaces is determined in conference by the engineering, shop, and inspection departments, is crude and costly in the extreme, and occasionally results in the acceptance of a finish which one of the departments concerned honestly believes is below that required for the particular mechanism in question. With suitable reference standards, together with a standardized procedure for obtaining these results, the costly conference arguments and the time spent in experimental try-outs can be practically eliminated; and in addition to this the cost-estimating and recording departments can do their work in a more positive way without the element of guessing, which now so frequently leads to the injection of a safety factor into cost estimates, this latter at times proving a real embarrassment to the commercial end of the business.

Discussions with the engineering and manufacturing personnel of many of the leading manufacturers in the mechanical-engineering industry, have convinced the writer that action in this direction is overdue and would be welcomed by all concerned, especially as in this move we have the opportunity for the establishment of manufacturing standards in a way which will not interfere with present manufacturing processes, and the reference standards cannot, from their very nature, be costly to manufacture. Furthermore the extreme simplicity of the scheme of finish designation will enable the standards to be established in both the engineering department and the shop with the least possibility of a misunderstanding.

R. E. W. HARRISON.[6]

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[5] "Standardization of Machining Finishes," by R. C. Deale. MECHANICAL ENGINEERING, October, 1931, pp. 723–728.

[4] President, Mattice Engineering Co., Philadelphia, Pa. Mem. A.S.M.E.

[6] Chief Engineer, Cincinnati Grinders, Incorporated, Oakley, Cincinnati, Ohio. Chairman, Cincinnati Section, A.S.M.E.

Engineering and Industrial Standardization

Fundamentals of Standardization in Practice

A PAPER on the use of standards by the Bell System was an important feature of the September 10th meeting of the American Standards Association Standards Council held at the Westinghouse Lighting Institute in New York. Cloyd M. Chapman, chairman of the Standards Council, was in the chair. The paper was presented by Dr. H. S. Osborne, transmission engineer of the American Telephone and Telegraph Company and alternate representative of the American Institute of Electrical Engineers on the Standards Council.

This illuminating description of the very complete way in which one large organization, which both manufactures and uses its product, employs standards, has been made available for free distribution by the A.S.A., so this note will be limited to a reproduction of a part of Dr. Osborne's remarks and his conclusions.

Perhaps the most useful type of analysis of the standardization work being done by the Bell System is to consider it in connection with the impelling motives which lead to standardization.

One of those motives in our case is the necessity of coordinating a far-flung and complicated telephone plant. The telephone plant covers the entire country. It is necessarily complex technically. The plant must be such in any part of the country that it will operate in coordination with the plant in any other part of the country, and that applies not only to the design of the plant but to its methods of operation. An example of standardization made necessary for this purpose is given by the electrical requirements placed upon the design of telephone circuits.

The extent to which that is an impelling motive in another industry may vary with the character of the industry. The second motive of which I want to speak is, however, one which is present in an important way in any industry which has rapidly changing conditions. I refer to the flexibility brought about by simplified practice. Conditions in the Bell System are rapidly changing, both because of growth in an ordinary year and changes in the actual instrumentalities with which the work is done. This means that in order to obtain the best ultimate economy and convenience, it is necessary to design each unit of the plant with a great deal of flexibility.

Closely associated with this motive is the motive of the economy which comes from mass production. The smaller number of articles that are produced, the more articles of each type are required with corresponding economies. For example, the Bell System has to use a great many electrical relays, and they must be put to a very wide variety of uses. By careful design of the parts it has been found possible to design one type of relay which is called the E type so that with minor changes of assembly of standardized parts producing different combinations of springs, the same relay can be used for a great many uses. The result is that that type of relay is produced in quantities of 2,500,000 a year and the identical spring assemblies are produced in quantities up to 200,000 or 300,000 a year.

Another impelling motive and one which is very important in the A.S.A. work, is safety. A good deal of attention has been given in the Bell System to developing standards of safety for construction, and it is found to be very valuable in that work to enlist the cooperation and interest of the construction employees themselves.

Another very important aspect of the safety work is developing standard provisions for safeguarding machines. By having standard safeguarding arrangements, an easy criterion is established for determining safety of new machines and the safeguarding provisions which are applied to them, and it is much easier to avoid the mistakes of improperly designed safety provisions.

Finally, an important motive in the standardization work of the Bell System is to make the best immediately available to all. Standards are developed as a result of the accumulated operating experience of the operating companies and of the general investigations of the headquarters department. When developed, information regarding new standards is immediately transmitted to all companies with recommendations regarding the field of use. These standards become standards in fact not because they are labeled standard, but because they represent the outcome of adequate studies of the best way to meet a certain situation. They are adopted by the companies in each case to the extent that they meet their conditions.

Another way in which standardization facilitates making the best available to all is that it simplifies development work. Modifications in existing systems or new systems must be designed to operate satisfactorily with existing telephone plant. The fact that existing plant is standardized makes fewer things with which the new things must be coordinated, and therefore simplifies development.

It perhaps is most accurate to speak of the use of standards as being the important thing, rather than the standards themselves.

If one stands on the step too long a time, he is not making progress up the hill. Let's always look upon standards as stepping stones to be used while preparations are being made for a better standard a little further up the hill, to which we can then move.

For many years standardization based upon not only the present needs of the telephone system but also on the best picture obtainable of future trends, has been an integral part of the program of development of telephone service. One type of standardization increases both the possibility and the advantages of another type, so that in such an organization standardization activities ramify through the entire structure and touch every part of the work.

The total economies resulting from standardization and simplification, of course, it would be impossible to closely estimate. Standardization has been productive of many advantages in addition to economy. These advantages may be summarized as follows:

1 Standardization makes the best available for all.

2 Standardization based on careful consideration of the requirements of the telephone subscriber results in more convenient and dependable service at lowest possible cost.

3 Standardization reduces the cost, because, when all companies use the same things they can be manufactured in the largest quantities, and uniformity contributes to economies in production.

4 Standardization reduces the cost of carrying stocks of materials and the cost of maintenance and repairs, because fewer parts have to be carried and maintained.

5 Standardization reduces the cost of instruction of new employees because there are fewer things with which to get acquainted.

6 Standardization reduces accounting costs because there are fewer types and sizes of materials to keep track of.

7 Standardization minimizes complicated engineering and operating problems that might result from intercommunication between widely divergent systems and apparatus.

8 Standardization renders available large supplies of materials and labor in emergencies.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the months of July 15 to October 15, 1931, as American Standards:

Safety Codes for the Installation of Pulverizing Systems for Sugar and Cocoa (Revision Z12b-1930); Prevention of Dust Explosions in Starch Factories (Revision Z12c-1927); Prevention of Dust Explosions in Terminal Grain Elevators (Revision Z12e-1928); Prevention of Dust Explosions in Wood-Flour Manufacturing Establishments (Z12g); Prevention of Dust Ignitions in Spice-Grinding Plants (Z12h); Use of Inert Gas for Fire and Explosion Prevention (Z12i).

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MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

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Reduction in Wage Rates

IN THE past month a large number of prominent industrial concerns other than railroads have cut wage rates, usually to the extent of 10 per cent. While this cut was initiated on a big scale by the United States Steel Corporation, it should be noted that the management of that corporation did all it could to prevent, or at least delay, taking such action. This is well illustrated by the address of President James A. Farrell at the spring meeting of the Iron and Steel Institute.

Cuts in the rates of wages may be considered from several points of view. It is pointed out by some economists that during recent years the cost of living has been going down, and that therefore a cut in wage rates of 10 per cent does not represent a reduction in real wages. Others stress that wages, as distinct from wage rates, have been seriously affected by short-time work and lack of employment.

Wages, which represent the total income of a majority of our industrial workers; wage rates, upon which this income is based; and real wages, which is a term used to indicate the purchasing power of money wages, and which vary with the cost of living, must be clearly differentiated in discussions of adjustments in wages.

The average worker is chiefly interested in total money wages over a period of time, that is to say, his yearly income. This income is affected by two important factors, the time worked, and the rate of wages. High wage rates do not yield high yearly incomes in times of depression and wage rates themselves will not keep alive unemployed workers whose habitual jobs entitled them to such rates. Real wages have an academic and statistical flavor. Reductions in the prices of clothing have little meaning to a man who is out of work, who is wearing clothes bought at top prices, and who is trying to pay rent, or taxes, or mortgage interest that may not have decreased. What each man wants is sufficient income or purchasing power so that he may assure for himself and his dependents the necessities of life, the standard of living to which he is reasonably entitled, and reasonable security for the future. Money wages, wage rates, and real wages are all concerned in this aspect of the question.

Wage rates in the steel industry were reduced "for the purpose of better meeting prevailing unsatisfactory conditions in the industry." This country has been the home of high wages and high standards of living. Certain economists have argued that the latter are the result of the former, and they still, in the present emergency, see in high wages a high consumer purchasing power, the maintenance of which is necessary for a revival of prosperity. Others hold to the principle of economic balance, and believe that until a proper balance is restored, a turn for the better cannot be expected. A reduction in wages, to counterbalance the lowering of commodity prices and the decreased cost of living, is an essential consequence of this point of view. As is natural, industry holds quite generally with the former and investors and bankers with the latter of these views.

Labor's point of view with respect to wage-rate reductions is obvious. Total wages are bound to fluctuate with good times and bad. But for the work done, labor argues, the rate of compensation, arrived at after long years of struggle, must be maintained through periods of depression if any real advance in the living standards of workmen is to be permanent. With a return to normal working hours, employees feel that they will find themselves worse off than before the depression, and forced to a standard of living lower than that to which they had attained.

Many factors are involved in this intricate question, and it is idle to predict which one will be most important in determining the workman's economic status in, say, 1935. Most persons will agree, however, that an improvement in the general standard of living is earnestly to be hoped for, and that it is not necessarily dependent upon a single economic factor, important as this factor may seem at the time.

Benefits From Reduction in Wages

JUDGING from the response of the New York Stock Exchange to wage reductions, it might be argued that a decrease in wage rates automatically means an increase in dividends. Actually there is no certainty whatsoever that this is the case.

It does not take buyers long to figure out that a cut of wages means a lower cost of production and that a lower cost of production should mean a lower card of prices. Thus the saving in wages may be reflected in a general lowering of prices in the basic industries where wage reductions have been brought about.

The basic industries, such as steel, copper, rubber, are working today at anywhere from 30 to 50 per cent of capacity. Even when the tide of business begins to come in, it will take a considerable time for the market requirements to grow up to the economical ratio of production to capacity, and until this happens no rise in price of any magnitude is likely to take place. The history of prices in the steel industry after the depression of 1921 shows that low prices once established have a tendency to stay down. If the present cut in wages causes a depression in the price level, will the rise of the price level antedate that of the wage level when business comes back, or will wages begin to rise before prices do? In other words, who will ultimately profit by the decrease in wages in the basic industries, the steel maker or the steel buyer? Historical parallels would tend to indicate that it is the latter who will profit.

An Engineers' Forum

HAVING noted from time to time in the daily press comments by engineers on topics of the day not always strictly within the field of engineering but intimately related thereto, it has seemed desirable to invite such comment, in the form of correspondence, for publication in **Mechanical Engineering**. Encouragement to put the intention to do this into effect came recently in a letter from a young engineer, who suggested that this journal establish a department in which its readers might discuss economic and related questions from their points of view.

The pages of **Mechanical Engineering** have always been open to its readers for the discussion of questions of interest to them. Comment on papers appearing in its columns has been published in the department entitled "Correspondence." This department is not restricted to letters dealing with papers published in **Mechanical Engineering**, however, nor to strictly engineering subjects. Engineers come into intimate contact with a great many non-engineering subjects. Their work influences and is influenced by these other matters. As educated men, engineers' opinions are as likely to be intelligently conceived as are those of any other group of men outside the ranks of those who have made special and professional studies. Economics, sociology, professional relations, civics, science, finance, domestic and foreign trade, public works, governmental policies, and many other groups of topics afford subject-matter for well-thought-out points of view that call for expression and make excellent reading material for others, whether or not opinions concerning them are unanimous.

Readers of **Mechanical Engineering** are therefore strongly urged to look upon this publication as a forum in which ideas may be expressed on a great variety of subjects. If a reader has given serious thought to a subject of importance, let him write to **Mechanical Engineering** about it. Only let it be remembered that sincerity, brevity, and good taste are essential. The editors, of course, reserve the right to reject communications that do not, in their opinion, serve the best interests of readers.

Rationalization's Defense

RESENTING the criticism so frequently heard that rationalization, or modern management, is responsible "for overproduction, for unemployment, for mechanization of work, for increased economic instability, and for imposing handicaps on weaker businesses and countries," participants in the Second International Discussion Conference of the International Management Institute at Geneva, July 4, 1931, passed a "Resolution on Rationalization" in which they examined the charges, made specific recommendations, reaffirmed their faith, and directed the Institute to continue its work. The resolution will meet with the sympathetic approval of engineers the world over.

On the score of overproduction the resolution recognizes that the rationalization of production increases the total quantity of goods on the market; but the remedy is found not in restriction but in an extension of the principles to effect a judicious reorganization of distribution processes. The recommendations propose agreements among producers to eliminate overproduction and national competition, the creation of international sources of information, and increase in consumption through growth of purchasing power made possible by lower costs and prices. Needless to say, some revision of our present laws would be necessary before all of these recommendations could be put into effect in this country. It is interesting to note, however, that variations of these recommendations are to be found almost daily in the press and come from men of great prominence.

"Technological unemployment," no new aspect of progress through the ages, is admittedly a result of rationalization. However, says the resolution, it is justifiable and productive, and carries its own remedies "since improvements in production, economy of human effort, and its liberation for alternative employment are a source of weath to the community." The resolution recommends efforts to assure judicious readjustment of employment, care for the unemployed until they can be re-engaged or transferred, and thorough discussion of the larger aspects of these questions between employers' and workers' organizations.

The monotony that may result from mechanization is recognized in the resolution, but there are countervailing conditions "in the elimination of exhausting and objectionable tasks, in better provision for health, in satisfaction in working in a highly organized and productive establishment, in the resultant improvement in general conditions both as regards wages and hours of work, and in widened opportunities for promotion." The recommendations include the "full utilization of the capacity and initiative of each individual" so that he may acquire additional technical knowledge, and the encouragement of means by which he may secure intellectual and cultural development and thus make better uses of his leisure.

In carrying out these recommendations every social, educational, and religious organization has even greater responsibilities than has management, for the proper uses of leisure can scarcely be determined solely by those agencies by which leisure is made possible.

The failure through rationalization to secure economic stability is attributed by the resolution to overambitious programs, resulting from errors of judgment; to its application to individual undertakings rather than progressively to industries as a whole, and then on a scale of national and ultimately international economy; and finally to the fact that the causes of the present depression lie outside of economic life. It is recommended that groups for the exchange of experience be formed; that professional institutions develop research, study, and statistics; and above all that the principles of rationalization be extended first to each profession and industry, and later to whole nations.

Mechanical engineers, who have been foremost in developing the principles and art of management, may be counted upon to extend its beneficent effects as widely and as quickly as possible.

Recognizing that rationalization may accentuate some of the handicaps of weaker industries, the resolution notes that weaker members of organizations can be insured against excessive risk "by reserving for them a proportion of the total business of the groups, which they can abandon under compensation when it ceases to be profitable." Here again are suggested trade organizations and agreements that would not be permitted under our present laws.

Finally, in considering social consequences, the resolution holds that rationalization is a working tool and a method, and cannot be held responsible for mistakes made in applying it. It is therefore recommended that all those who seek for a rational organization of their businesses should pay the "closest attention to the social consequences of the measures which they adopt, with particular reference to the moral and physical conditions of their factories, fair treatment of their workers, the prosperity of those who are dependent on them, and provision for and use of leisure."

It is one of the distinctly encouraging signs of the times that modern industry, taken by and large in this country, is actuated more and more by a spirit of social obligation. Mr. Ralph E. Flanders has given to this spirit the name of "enlightened self-interest." It is undoubtedly true that we owe the development of this spirit to the growth of a great body of trained men who are neither workers nor employers but both, professional managers, who have found quite universally in "enlightened self-interest" the "one best way" for industrial progress. It is a fair observation that we shall probably find eventually that the contributions these men are making to social welfare and progress are as important and significant as any that the world has yet received.

The British Pound

THE causes which led the British government to abandon the gold standard have profoundly affected the entire structure of British economic life. Only the main elements entering into this highly complicated situation can be reported here.

Unlike the other great nations, Great Britain did not materially reorganize its national production plant as a result of the war. The progress in American industries is too obvious to require comment. After the war Germany profited in part by the deterioration of currency to obtain cheap labor and materials, and also by enormous foreign borrowings to provide capital, and thereby thoroughly reorganized its plants. This reorganization was in part an enforced one due to the requirements of the Versailles Treaty that war plants be either closed or converted to peacetime production.

The manufacturing facilities of Belgium and northern France were, of course, completely destroyed by the Germans. They have since been rebuilt in part by loans from the national treasuries and in part by reparations from Germany, with the result that today French and Belgian industries are of a more up-to-date character than they have been in a long time.

Great Britain was not called upon to carry out similar reconstruction of its industrial plants either by treaties or by the force of facts. Its industries were badly disorganized during the war by a shift from a peace to a war basis. In converting these plants back to a peace basis the same care and generosity were not exercised, and British industrials, certainly in the majority of cases, did not have access to cheap money to modernize their plants themselves. The result is, as shown by the Replogle investigation of the steel industry and by an investigation of the textile industry carried out by London bankers, that industrially Great Britain is behind not only the United States but also Germany, France, Belgium, and perhaps even Italy. Being the hindmost in the highly competitive field of world industries today is more than an invitation to the devil to exercise his proverbial habit.

Another fundamental disturbance to British economic life is to be found in the disorganization of the coal industry. Coal has always been one of the major sources of national income for Great Britain. Enormous quantities of it have been sold on the Continent, as far as St. Petersburg, Russia, and in addition there has always existed a very profitable trade in bunkering coal. However, several circumstances have cooperated in beggaring King Coal. Italy is taking less than ever before, because of the development of water power and, more recently, because of supplies from the Black Sea ports of Soviet Russia. A heavy blow to the bunkering-coal trade was dealt by the development of the motorship which, instead of British coal, makes use of Mexican and South Asiatic oil. To aggravate matters still further, engineering progress has cut down the domestic consumption.

Shipping, another stand-by of British finances, has been less and less profitable as the years have passed since the war. The restriction of immigration to the United States, the creation of an American merchant marine, such as it is, the remarkable reconstruction of German shipping, have affected British profits.

Finally, the so-called invisible imports, while still very huge, have dwindled considerably in the last two decades. During the war the United States instead of being one of the largest debtors of England became its creditor. Russian securities, which were held in England to a considerable extent, lost practically all value. Disturbances in other parts of the world where British capital was financing industrial developments depreciated other holdings. Countries that had previously provided markets for British goods had found other sources of supply or had used the machinery sold to them by Great Britain to satisfy their own needs. Furthermore, the best securities which were held in England before the war were sold to provide gold exchange abroad for the purchase of munitions and food. In addition to these difficulties, the stabilization of the British pound at prewar par proved a severe strain on the financial structure. All of these factors, together with a good many which cannot be discussed here, in particular budget deficits due to the dole, brought about a situation in which any delay in the suspension of free gold exchange would have simply resulted in the complete draining of gold resources from England and a suspension of the gold standard under conditions much worse than the present ones.

Economists long ago recognized that the ability to maintain the gold standard could not exist unless accompanied, or rather preceded, by a sound economic structure. It is like the temperature of the human body. It can be maintained at normal by doses of aspirin, but aspirin will not cure the diseased condition which causes the temperature to deviate from normal. Only when the British economic system shall have been properly reconstructed may a return to the gold standard be expected.

The National Metal Exposition

THE National Metal Exposition held in September at the Commonwealth Pier in Boston provided a general survey of what might be called the finer steel and accessory industries. But little of the progress made in the manufacture of straight carbon steel, particularly the heavy shapes, was evidenced by the exhibits; on the other hand, the alloy-steel industry, the treatment of steel, welding, and testing were amply and very interestingly represented.

One of the most significant features of the exposition was the large number of devices shown for the control of operations. Even a brief walk through the aisles served to indicate that, at least in the finer steel industries, the days of conjecture and intuition are rapidly passing. This is only natural, since, like the little girl with the curl, when alloy steels and heat-treated carbon steels are good they are very, very good, and when they are bad they are horrid—and being horrid at the price of some of the alloy steels today is decidedly unprofitable.

It is apparently for these reasons that annealing furnaces are now equipped with atmospheric control to prevent scaling and burning of the work. Similar atmospheric control is to be found in nitriding and carburizing furnaces.

The exhibits comprised numerous mechanisms for the accurate control of furnace temperature, so devised as to eliminate as far as possible the human element. Pyrometers and recording instruments are becoming better and better. There are now available potentiometer-type pyrometers with improved balancing mechanisms to provide faster recording and micrometer sensitivity. The three-position type of controller has been evolved for continuous furnaces in which sudden temperature fluctuations are apt to take place and the average load varies considerably.

A universal testing machine was shown which is provided with a new straining and weighing system; also a dilatometer for determining critical temperature and coefficient of expansion combined with a laboratory furnace for heating.

An electric furnace shown was equipped with an electromagnetic winding which makes it possible to determine the Ac_2 point of the steel within the furnace. This is a far cry from the famous Welsh open-hearth foreman who could tell the quality of steel by the smell.

Mention must also be made of apparatus for magnetic analysis by means of which an oscillogram is produced indicating not only the presence of such defects as cracks, but also the presence of inclusions, notably carbide segregations, and differences in carbon content or hardness.

Only a few of the general exhibits can be referred to here because of lack of space, those of particular interest to mechanical engineers being given preference. Among these may be mentioned the metal "Ramet," a tantalum carbide composition for use in practically the same work for which tungsten carbide materials are employed. It is chiefly used in the form of tips brazed on to tool-steel shanks. Incidentally, though it was not announced at the exposition, it is said that a German concern has developed a method of producing tungsten carbide tools without the use of such matrix materials as nickel and cobalt.

One company exhibited an automobile crankshaft with a nitrided surface and an aluminum connecting rod working on this surface without the interposition of any white-metal bearing material. It was stated that the Citroën Company, of France, is using such crankshafts and connecting rods as standard on its cars.

A muffler was shown in which the gases move in curved paths and pass out through large ports. It is intended particularly for use on boats equipped with Diesel engines.

Welding has been successfully applied to the production of new materials. One such material consists of steel parts, such as rods, on which a very hard surface is welded. The surface material may contain tungsten carbide and other alloys.

Another company exhibited a combination consisting of 80 to 90 per cent open-hearth steel to which is veneered by a welding process from 10 to 20 per cent of rust-resisting steel.

A somewhat similar product consists of ordinary cold-rolled strip steel either copper plated or zinc plated. Incidentally, bright cold-rolled strip steel is now available with such specifications as 0.015 in. thick and 30 in. wide. Only a short time ago the extreme width in so light a gage was about 12 in.

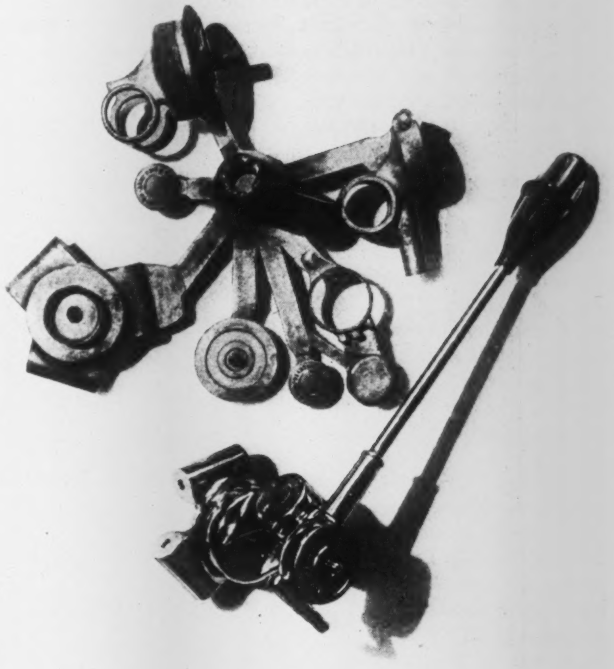
The use of flexible shafts is apparently increasing in industry. One such shaft was exhibited with a power output varying from a fraction of a horsepower to $2^1/_2$ hp. together with a number of tools that can be driven by such a shaft, such as buffers, sanding drums, drilling gear, grinding wheels, and machines for screw driving and nut setting. The latter work up to $^1/_4$-in. screws has hitherto always been a problem, as uniform as well as adjustable tension, with a tool powerful and yet light in weight, was essential. The same machinery may be used for rotary and reciprocating filing, chasing, sawing, snagging, and shearing.

An interesting exhibition of what modern metals can do in the way of heat resistance was shown by a clock made by a company manufacturing heat-resisting alloys. It was stated that this clock had operated successfully and kept excellent time while in a heat-treating furnace at a temperature of the order of 2000 deg. fahr. It was, of course, driven by a weight, but a visitor was heard gravely to ask of what material the springs were made so that they would not lose their tension at the elevated temperature mentioned.

Shakeproof lock washers were shown. These are washers provided with internal or external twisted teeth which bite into both nut and work surface, forming a contact that only applied pressure can release. They are made of phosphor-bronze, brass, or steel, in the latter case being heat-treated.

A rotary pickling machine for small parts was shown. It consists of several connected sections, of which the first is a pickling drum lined with rubber vulcanized to the shell. This drum rotates at 6 r.p.m., agitating the work in a flowing bath of dilute sulphuric acid. The agitation is gentle enough to permit the handling of soft threaded work without danger of marring. The acid is pumped into the drum from a lead-lined tank and drains back into it, the circulation being continuous.

From the pickling drum the work is discharged into a continuous screen made of acid-resisting material where the metal is first drained, then rinsed in a spray of water, and finally drenched with a fluxing solution of zinc chloride or hydrochloric acid. The parts used in demonstrating the machine, which were small forgings, came out copper plated. This was due to the transfer of that metal from the screen.



DIE-CAST ZINC TRIPOD HEAD FOR A 16-MM. MOVING-PICTURE CAMERA

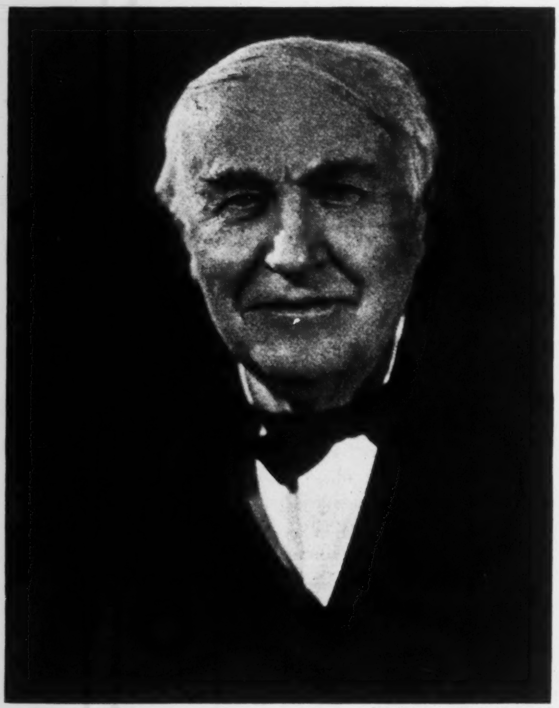
(All of the zinc die-cast parts for the assembly are cast in a single die.)

An interesting exhibit showing numerous zinc die castings was significant both because of the remarkably clean and smooth surface of the castings and also because of the manufacturing possibilities which this method of production permits. Among the castings exhibited was a tripod head for a 16-mm. moving-picture camera in which all of the zinc die-cast parts for the assembly were cast in a single die attached to the central hub by a series of arms, as shown in the accompanying illustration. All that it is necessary to do is to cut off the parts from the respective arms, and such is the excellence of the castings that many of the surfaces are not machined or finished in any way. These castings can be plated, for example, with chromium, and the new die-casting alloys are of sufficient strength to be used in making such articles as golf-club heads.

Contrary to the general expectation, no very significant new developments in the art of welding were exhibited. One company showed tubing longitudinally welded by the electrical resistance process both as it left the welding apparatus and as cleaned up later. Another company showed pipe longitudinally welded by the acetylene process.

Thomas Alva Edison, 1847–1931

HONORED throughout the world as the great inventor whose genius and vision brought light to the modern world in the form of the electric incandescent lamp, Thomas A. Edison, probably the most popularly known inventor of all time, died at his home in Llewellyn Park, New Jersey, on October 18. Not only did he develop the incandescent lamp and bring it to commercial success, but he devised the machinery for generating the needed electrical energy and established the central electric-light station and distribution system. A description of the Edison steam dynamo installed in a central station in New York City, written by him and Mr Charles T. Porter, who provided the high-speed steam engines for driving some of the direct-current generators, was presented to the A.S.M.E. in 1882, and published in Volume 3 of the Transactions. The growth of the electric light and power industry from such modest beginnings into one of the greatest and most important of our public utilities is one of the most amazing developments of the past 50 years. The electric industry has been built upon Mr. Edison's discoveries. No other industry owes so much of its inspiration and progress to the outstanding genius of one man. Nor were his efforts confined to a single field, but wherever new discoveries could result in benefits to mankind, there he was found laboring at all hours of day and night. The value of Mr. Edison's contributions to the welfare, comfort, and needs of mankind will increase continually, as on them will be founded many new developments in years to come.



Underwood and Underwood

THOMAS A. EDISON

In addition to Mr. Edison's many inventions connected with electric lighting, were hosts of others in many and varied fields. The invention of the phonograph would have brought him world renown had he made no discoveries in electricity. He assisted Sholes, who developed the typewriter as a commercial success, to make the first successful working model. The mimeograph and the dictograph represent other aids to business resulting from his genius. His invention of the quadruplex system of telegraphy saved the investment of many millions of dollars in wires. He discovered a previously unknown and unique electric phenomenon, which he called "etheric force," and which became the foundation of wireless telegraphy. As long ago as 1883 he made a discovery which today covers the foundation principle on which the modern radio tube is based. He invented the carbon telephone transmitter which made telephony a commercial art. This invention included the microphone which makes radio possible. In 1891 he developed the motion-picture camera, and 21 years later introduced the kinetophone or talking motion picture. The years 1900 to 1910 were devoted largely to the establishment of his portland-cement mill, and to the development of the Edison alkaline storage battery. The latter was constructed according to entirely new principles and required an enormous amount of experimenting.

One could go on indefinitely listing the accomplishments of Mr. Edison which have affected a score or more of industries. It is said that his discoveries are the basis of world investments totaling more than 15 billions of dollars. During the World War he worked on some 42 major problems as president of the Naval Consulting Board, giving up his entire time to this work for two years. One of his latest investigations was that of producing rubber from goldenrod.

Some one has referred to Mr. Edison as being "thoroughly comfortable and undeniably human." Among his chief characteristics have been marvelous alertness, indomitable determination, and mercurial energy. He was always a simple, unaffected human being, interested in everything. He had wonderful powers of concentration, and this has often been referred to as being a result of his deafness.

Mr. Edison was born February 11, 1847, at Milan, Ohio, the son of Samuel and Nancy Elliott Edison. His early education came principally from his mother, a highly educated woman with long experience as a teacher. At an early age he showed a fondness for chemistry. The story of how he became interested in electricity through his learning to be a telegraph operator has been published many times. His interest in telegraphy lay chiefly in a desire to improve the equipment and methods used, but he reached a degree of proficiency as an operator that resulted in many stories of his skill.

In 1873 Mr. Edison was married to Miss Mary G. Stillwell, who died nine years later, leaving him three children, Thomas Alva, Jr., William Leslie, and Marion Estelle. He was married a second time, in 1886, to Miss Mina Miller, and of this union there were also three children, Charles, Madeline, and Theodore. The Edison home, purchased in 1886, was but a few minutes' walk from his laboratory. One of the rooms in the house most used by Mr. Edison was his "den." Here in a large glass case was a collection of medals and decorations conferred upon him, for few men have had more honors showered upon them during their lives. Among these were three degrees of the Legion of Honor, Chevalier, Officier, and Commander, and many other decorations, medals, and interesting letters from kings, prime ministers, scientists, and other notables. He received the Rathenau Medal from Germany, the John Fritz Medal in 1908, and the Congressional Medal in 1928.

Mr. Edison was an honorary member of The American Society of Mechanical Engineers, of the American Society of Civil Engineers, and of the Engineers' Club, New York City, and a member of the American Institute of Electrical Engineers and of the American Institute of Mining and Metallurgical Engineers.

A more detailed account of Mr. Edison's unparalleled achievements and inventions will appear in the A.S.M.E. Record and Index.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

"Hütte"

"HÜTTE," DES INGENIEURS TASCHENBUCH, 26 Auflage, 1 Band. Akademische Verein Hütte. W. Ernst u. Sohn, Berlin, 1931. Cloth, $4\frac{3}{4} \times 7$ in., 1199 pp., diagrs., charts, tables, 17.50 r.m.

THIS is the first volume of the 26th edition of the famous German engineering handbook. It deals with mathematics; mechanics; technical physics; heat; strength of materials; engineering materials, including castings, forgings, and alloys; ferrous and non-ferrous, as well as non-metallic materials; and methods of measurement, including geometry and surveying. An appendix gives the weights and measures used in 40-odd countries, together with their metric-system equivalents. Like its predecessor, the book is full of interesting information in the German language and German units. The majority of references made to previous publications are to material published in the German language, the work of English and, particularly, American engineers being cited only in comparatively few cases.—L. C.

Gasoline and Heavy-Oil Aircraft Engines

FLUGMOTOREN IN LEICHT- U. SCHWERÖLBAUART. By W. Thoelz. Richard Carl Schmidt & Co.. Berlin, 1931. Cloth, $5 \times 7\frac{3}{4}$ in., 352 pp., 22.50 r.m.

THIS book forms one of a series of Dr. W. Haeder's handbooks of machine construction. It is partly descriptive, but deals largely with the methods of calculating the various machine parts. From this point of view it may be said to be unique, and it will be found valuable by designers of internal-combustion engines because of the great mass of construction details which it presents. The book is profusely illustrated by diagrams and drawings, but contains practically no halftone illustrations. It deals in considerable detail with both gasoline and the heavy-oil engines, but is limited to the field of aeronautical motors.—L. C.

Business Administration

BUSINESS ADMINISTRATION. By Willis Wissler. McGraw-Hill Book Co., Inc., New York, 1931. Cloth, 6×9 in., 897 pp., illustrations, diagrams, tables, $5.

REVIEWED BY WALTER RAUTENSTRAUCH[1]

A BOOK which presents the problems of business administration in large perspective is a welcome addition to a rapidly growing literature. The book under review is of this nature. It is a thought-provoking text designed to confuse the simple minded who look upon business as a succession of shrewd deals for immediate profits, but to enlarge the horizon of thought of creative minds who are seeking the broader implications of the interplay of economic forces in our social growth and advancement.

As an introductory text for students of business who will pursue more detailed studies in commerce or industrial management, it is to be recommended.

Many chapters could be expanded profitably to comprise an entire volume, which is but natural in a book of this character. The first chapter, entitled "The Contemporary Scene," is a brief statement of economic statistics together with a few philosophical observations relating to the present trend of events in business. In the second chapter, on "The Method of Approach," the institutional character of business is stressed.

A brief chapter on "Historical Backgrounds" sets forth the causes which gave rise to the factory system. A few pages on the fundamentals of organization constitute the fourth chapter. Money, banking, and credit are dealt with in the fifth and sixth chapters, consisting of about fifty pages altogether.

In the seventh chapter the author attempts to state the principles of accounting, define balance-sheet ratios without defining the terms, state the items of manufacturing cost, define depreciation and obsolescence, and discuss business cycles and budgeting. This chapter seems like the stenographic notes of a casual discussion of those topics. To state that the "cost factors" are "A, direct or prime cost, B, indirect costs (overhead or burden), and C, overhead or burden," is confusing. That "the foreman or production executive—does need to be, to some extent, a cost engineer" is a rather loose statement. What is a "cost engineer"?

Chapters VIII–X deal with the problems of distribution in a clear and systematic manner, the last one describing the mechanisms and channels of distribution in both domestic and foreign trade.

The next chapter, on "Price Fluctuation," although short, presents much material for interesting class discussion. Chapters XII and XIII are devoted to the problems of "Industrial Relations" and "Personnel Administration," and together with the two succeeding chapters, on "Labor Management" and on "Industrial Democracy," comprise 135 pages and constitute a comprehensive survey of the labor problems in industry and the devices in organization, wage payment, and social legislation which have been operating toward their solution. The work of Taylor and the scientific-management movement is presented in these chapters. Wage-payment methods are too briefly discussed, and the trends of social legislation could have been presented more fully. The presentations of the problems are clear, sensible, and interesting. The merits and faults of Taylor's philosophy of management are frankly presented, and the evaluations of certain "movements" are admirable. One leaves these chapters with a feeling that a whole semester's discussions are found here. The teacher who does not have experience in industry had better avoid these chapters if he has a bright class of students.

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[1] Professor of Industrial Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

Under the heading "Man and Machine," in Chapter XVI the author points out the economic import of the use of machines in production. The point of view presented is indicated in the following statement, taken from the "summary and conclusions:" "Labor groups, vividly aware of the discomforts of technological unemployment, have for the most part struck blindly at the mechanism of an industrial order, when what really occasioned their discomfort came, not out of the structure of industry, but out of the kind of capitalism which has shaped it." Unfortunately the author does not make use of the available statistics on technological unemployment to illustrate his arguments.

Chapter XVII, on "The Factory System," is disappointing; dealing largely with statistics of growth in productivity and the influence of inventions, it fails to give a clear picture of what the factory system really is. Transfer of skills, specialization of labor, standardization, limits of dimension, are among the basic features of the factory system not alluded to.

In the eighteenth chapter, "Production Control: Manufacturing," the author deals with the problems of plant location, plant layout, operation analysis and method study, the master schedule and dependent budgets, routing and dispatching, as well as burden or overhead, all in thirty-six pages. The presentations of the several subjects are meager and inadequate, and some do not belong in this chapter.

"Production Control: Agriculture" is the subject of Chapter XIX. It is interesting reading, but the reviewer is not sufficiently familiar with the literature of this subject to be able to judge its value.

Four chapters (XX–XXIII) are devoted to the materials problem. Interesting statistics are given on waste in industry and methods of conservation. Purchasing and inventory control and the principles of storekeeping are briefly discussed. Traffic management, warehousing, and shipping are treated in a single chapter. Balancing materials supply with sales demand in relation to other factors such as economic lot sizes in production is also discussed.

Some of the psychological aspects of management are discussed in chapters on "The Human Equation" and "The Silent Organizations," the latter dealing particularly with record keeping and office management. Methods and means for industrial research are discussed in Chapter XXVI, under the heading, "The Quantification of Managerial Control."

The last four chapters treat of the social consequences of industrialism under the headings "Social Percussions of the Machine," "Business and the State," "Mechanics of Progress," and "Conclusions."

Each chapter of the book closes with a "Summary and Conclusions" and "Cues for Discussion and Debate," the latter being quotations from writers in many fields of thought.

The style is clear and interesting. It is a good textbook for a survey course in business problems, and should prove stimulating to a wide range of business executives.

The printing and illustrations are very good, as are the other mechanical features.

The author is professor of industrial research in Ohio State University.

Third International Congress for Applied Mechanics

Proceedings (Verhandlungen—Comptes Rendus) of the Third International Congress for Applied Mechanics, Stockholm, Aug. 24–29, 1930. Sveriges Litografiska Tryckerier, Stockholm, 1931. Cloth, $8^1/_4 \times 10^1/_2$ in., 3 vols., 1288 pp., drawings, tables, plates, $50.

Reviewed by S. Timoshenko[2] and J. P. DenHartog[3]

THE reports of the Applied Mechanics Congress in Stockholm represent work of great interest to engineers. They give a clear picture of the progress and new developments in the field of applied mechanics during the last four years. The numerous papers are subdivided into three volumes: Volume I contains the papers on hydromechanics and aerodynamics (reviewed later by Mr. DenHartog), Volume II those on elasticity, plasticity, and strength of materials, and Volume III the contributions on elastic stability and vibrations.

Volume II begins with a general lecture by R. v. Mises considering various strength theories and conditions of plastic flow. Following this come several papers dealing with these fundamental subjects, among them being the papers by A. Nadai and Pollaczek-Geiringer, discussing plastic flow in the case of two-dimensional problems, and one by M. Ros and A. Eichinger in which an attempt is made to predict the strength of a crystalline specimen when the mechanical properties of a single crystal are known. There are several papers discussing stresses in machine parts and stress concentration produced by holes. Among these may be mentioned the contributions by E. Honegger and by A. M. Wahl in which a detailed analysis of the stresses in close-coiled helical springs is given and Belleville springs are also considered. The paper by R. C. J. Howland gives the solution of the problem of stress concentration produced by a circular hole if the width of the plate is not very great in comparison with the diameter of the hole. In the paper by Nobory Yamaguti an experimental investigation of the stress distribution in a tunnel is given. Of special interest to designers is the paper by Ziro Tuzi, which tells of the progress in photoelasticity recently made in Japan (fringe method). The application of cinematography in photoelasticity is also described in the same paper. Mention should also be made here of the paper by H. M. Westergaard describing the principles of the analysis of arch dams.

Volume III begins with a general lecture by S. Timoshenko on the stability and strength of thin-walled constructions. These problems on stability are especially important in the design of such structures as bridges, airships, and airplanes. The elastic stability of a thin plate under compression is discussed in the papers by G. Schnadel and E. Melan. The important problem of the stability of a rectangular plate under the action of shearing stresses is discussed in the papers by S. Bergmann and E. Seydel. Stability of beams of variable depth against lateral buckling is discussed by K. Federhofer, and a general discussion of the stability of a compressed bar, using the theory of large displacements, is given by E. Trefftz.—S. T.

Volume I deals entirely with hydrodynamical and aerodynamical questions. Besides many original contributions, there are a number of excellent papers, reviewing the progress made during the four years since the Zurich Congress. These latter are based on previous publications in various periodicals, and give a comprehensive view of the present status of their subjects. Outstanding among these are four "general lectures," in which

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Oseen (in German) gives a summary of the endeavors made to solve the question of turbulent flow, or mathematically speaking, to find approximate solutions with physical meaning of Stokes' differential equation; Eisner (in German) discusses the problem of resistance to flow; Bairstow (in English) gives the theory and precalculation of airscrews especially with regard to methods used in Great Britain; and Wigley (in English) writes about the newer theories of Havelock and Hogner on ship resistance. This last subject has assumed a decidedly theoretical aspect, involving much mathematics. As a whole, these four "general lectures" are intensely interesting, written as they are by the outstanding authorities on their respective subjects.

The remainder of the volume comprises fifty-three papers. Among those of direct interest to engineers is a contribution by Nökkentved (in German) on tests to determine wind pressure on buildings. The results differ widely from the usual calculations of wind pressure given in handbooks. Another paper, by Tanaka (in English), deals with flow through poppet valves; good photographs are given, and also some experimental results of interest to gas-engine builders. Hanocq (in French) discusses a feature in bearing testing machines. It has been assumed as self-evident that the friction torque transmitted by the shaft to the bearing is the same as that from the bearing to the shaft; and in bearing testing machines this property has frequently been used for measuring the friction torque on the bearing, which was floating on the shaft for that purpose. Since, however, the shaft runs eccentrically in the bearing, the two moments are *not* equal, and errors in the friction torque as great as 100 per cent can be made by measuring the torque on the bearing instead of on the shaft. Another paper on lubrication, by Karelitz, summarizes his previous papers before the A.S.M.E. A paper by Seelig (in German) discusses Föttinger's effect of "superturbulence." When a U-shaped tube is rotated about the horizontal axis through the top points of the legs of the U, the resistance to flow of water through the U-bend when rotating may be up to 100 times as great as when standing still. This effect is of importance in hydraulic couplings where oil is flowing through channels which are rotating with the shaft. Betz (in German) contributes a paper on cavitation in ship propellers, and gives some suggestions for possible improvement.

Turning now to papers which are directly concerned with aeronautics, an outstanding contribution is by Glauert (in English) on high-speed airscrews. Wagner (in German) calculates the pressures created when landing a hydroplane on a calm sea. Jones (in English) reports on experiments made in Great Britain on the motions of airplanes in flight which are purposely stalled. This paper is a review of past work which has been published in the British "Reports and Memoranda." Briggs and Dryden write on lift-drag diagrams obtained in this country with speeds approaching the velocity of sound.

The subject of turbulent flow through pipes, with closely associated discussions on dimensional analysis, is treated in papers by Messrs v. Kármán, Lorentz, Treer, Körner, Schiller, and Nikuradse in German, and by Szymánski in French.

Meteorological applications are discussed by Bjerkness and Solberg (in German) and by Low (in English). Tietjens (in English) presents some experimental results on flow with very small Reynolds numbers, while Farren (in English) describes a water tank capable of giving pictures with very large Reynolds numbers.

Regarding the more theoretical papers, there is a contribution by Tollmien (in German) in which he calculates the critical Reynolds number for flow in pipes. An interesting paper by Taylor (in English) deals with the solution of the flow problem, taking into account compressibility, using successive approximations by means of tests in an electric tank. When the velocity of sound is exceeded in certain parts of the current field, the approximation ceases to be convergent. Exact solutions (without practical application for the time being) of Stokes's differential equations are given by Rosenblatt (in German), and by Kampé de Fériet, Wytoszynski, and Szymánski (in French). Several authors have calculated special cases of potential flow with the methods of conformal mapping (with or without Helmholtz' surfaces of discontinuity): namely, Dentchenko, Pavel, Métral, and Dupont in French, Kawada in English, and Linderer and Mueller in German.

Finally, there is a paper by Pavlenko (in English) on the theory of the aquaplane, or flat-bottomed speedboat. He considers an infinitely wide board being pulled over the water. A formula for the resistance is deduced which gives a value only a few per cent of the actual one, since the "induced drag" of the ends is neglected.

The (greater) part of Volume III not reviewed by Dr. Timoshenko deals with vibration problems. Three "general lectures" are included, one, by Panetti (in Italian), reviewing the existing literature on vibrations in side-rod electric locomotives and automobiles; another, by Michel (in German), on building acoustics, and a third, by Moullin (in English), on ship-hull vibrations. The last paper is interesting inasmuch as it draws attention to the pronounced influence of the surrounding water on the period of vibration and on the damping.

Among the "sectional lectures," a calculation by Nicolai (in German) is interesting because of the paradoxical result to which it leads. It is claimed (by theoretical calculation) that shafts running below as well as above their critical speeds are unstable when subjected to a torque. Since this is the case with most shafts, the result seems to be against actual experience, so that it is to be regarded very skeptically. Van den Dungen (in French) proposes the use of "harmonic influence functions" (parallel to the well-known ordinary or static influence functions) in calculations, which type of function he defines as the shape a beam takes under the influence of a harmonically pulsating unit force. It seems that the use of these functions may shorten calculations in certain classes of problems. Klotter (in German) has a paper on beam vibrations, which is made additionally interesting by a brief but excellent discussion thereon by Southwell. An exact solution of the problem of nodal lines in rectangular plates with free boundaries is found in a paper by Grauers (in German). This problem is of importance due to its history. Chladni observed the figures experimentally about 1800, and several investigators have tried to explain them, and a very good *approximate* calculation was given by Ritz in 1902, using the now famous Ritz method. The contributions by Van der Pol (in English) and Liénard (in French) deal with self-induced vibrations. Le Vorbeiller (in French) gives a discussion of governor vibrations, introducing electrical analogies which comprise vacuum tubes and using Van der Pol's results.

Meissner (in German) discusses the theory of a damper of the non-uniform rotation of a shaft, consisting of mercury which can oscillate in certain channels mounted on the shaft. Papers by Bréguet (in French) and Küssner (in German) deal with airplane vibrations, and Fromm (in German) presents an excellent theoretical and experimental treatment of automobile shimmy and similar phenomena.

Langer and Shamberger give details of an interesting method of determining locomotive vertical and lateral wheel loadings by means of stress measurements on the rails. Further papers by Newkirk, Kimball, Ormondroyd, DenHartog, and Eksergian deal with subject-matter which has been published in this country previously. Lack of space prohibits mention of many other good contributions dealing with various ramifications of vibration theory.—J. P. D.

A.S.M.E. 1931 Annual Meeting Papers

Available About November 15 in Pamphlet Form; Order by Number—Order Blank on Page 862

(1) Alden, J. L., Machine-Design Management
(2) Allen, Charles M., and Hooper, Leslie J., Piezometer Investigation
(3) Atwater, K. W., Millwright Bearings for Roll Necks of Medium-Sized Rolling Mills
(4) Bausch, Carl L., Coordination of Research and Engineering With Production and Sales
(5) Beitler, S. R., Bucher, Paul, and Barnes, T. C., Jr., A Study of Primary Metering Elements in 3-In. Pipe
(6) Boston, O. W., and Kraus, Charles E., The Elements of Milling
(7) Bradford, Louis J., Oil-Film Pressures in an End-Lubricated Sleeve Bearing
(8) Busse, W. F., and Denton, W. H., Water-Lubricated Soft-Rubber Bearings
(9) Cluett, Sanford L., The Sanforizing Process
(10) DenHartog, J. P., and Mikina, Stanley J., Forced Vibrations With Non-Linear Spring Constants
(10a) Edmonds, R. H. G., and McMinn, B. T., Celluloid as a Medium for Photoelastic Investigation
(11) Elmer, Nixon W., Rustless-Steel Conveyors—Their Availability, Application, and Use
(12) Field, E. G., Dividend Programs Related to Depreciation
(13) Fisk, G. L., Recent Developments in Merchant-Bar Mills
(14) Foulk, C. W., Foaming and Priming of Boiler Water
(15) Fowle, Edwin D., Cause and Effect of Recent Advances in Textile Machinery
(16) Frocht, Max M., Kinematography in Photoelasticity
(17) Frymoyer, W. W., and Herschel, A., Flow of Steam Through Square-Edge Orifices in 4-In. Line
(18) Gechter, O. F., and Laird, H. R., Improved Device for Recording Instantaneous Tool Pressures in Machinability Studies
(19) Gibson, Holbrook, United States Navy Diesel-Engine Requirements
(20) Goodier, J. N., Compression of Rectangular Blocks and the Bending of Beams by Non-Linear Distributions of Bending Forces
(21) Heinz, W. B., Design Problems of Controllable-Pitch Propellers
(22) Hensel, F. R., and Tichvinsky, L. M., Straight Copper-Lead Alloys Versus Leaded Solid-Solution Bronzes for Heavy-Duty Bearings
(23) Hirshfeld, C. F., and Moran, G. U., Performance of Modern Steam-Generating Units
(24) Jackson, L. B., Small Marine-Diesel Installations
(25) Kingsbury, Albert, Optimum Conditions in Journal Bearings
(26) Langmuir, I., and Westendorp, W. F., A Study of Light Signals in Aviation and Navigation
(27) Larson, C. M., Oil Requirements for Modern Rolling-Mill Circulating Systems
(28) Lupien, U. J., Foremanship Training
(29) MacDonald, H. N., Improved Material-Handling Methods in a Container Plant
(30) MacMeeken, J. W., Turbulence in Centrifugal Pumps
(31) Mahon, Ross L., Hydraulic Butterfly Valves
(32) Marks, Lionel S., and Winzenburger, E. A., The Influence of Inlet Boxes on the Performance of Induced-Draft Fans
(33) McKee, S. A., and McKee, T. R., Pressure Distribution in Oil Films of Journal Bearings
(34) Merrill, Jos. A., and May, Edwin M., Modern Oil-Lubrication Methods as Applied to Rolling-Mill Equipment
(35) Nicholls, P., and Reid, W. T., Fluxing of Ashes and Slags as Related to the Slagging-Type Furnace
(36) Ormondroyd, J., and Kuchler, T. C., Design of Spring Gears for Exhaust-Turbine Installation
(37) Partridge, Everett P., Schroeder, W. C., and Adams, R. C., Jr., The SO_4-CO_3 Ratio for the Prevention of Sulphate Boiler Scale
(38) Potter, A. A., Solberg, H. L., and Hawkins, G. A., Characteristics of a High-Pressure Series Steam Generator
(39) Preble, N. H., Application and Design of the Floating Drive for Conveyors
(40) Schroeder, W. C., and Fellows, C. H., Determination of Carbonate, Hydroxide, and Phosphate in Boiler Waters
(41) Schmitt, A. J., Application of Celoron Bearings to Roll Necks
(42) Sellers, Coleman, 3rd, Tungsten Carbide and Other Hard Cutting Materials, Progress Report No. 3 of Subcommittee on Metal-Cutting Materials
(43) Seyler, George A., Modern Industrial Training
(44) Smith, A. R., and Hanson, H. B., Ford Motor Company's 1200-Lb. Steam-Plant Installation
(45) Solakian, Arshag G., and Karelitz, George B., Photoelastic Study of Shearing Stresses in Keys and Keyways
(46) Stepanoff, A. J., Leakage Loss and Axial Thrust in Centrifugal Pumps
(47) Straub, Frederick G., Solubility of Calcium Salts in Boiler Water
(48) Taub, Alex, Correlation of Design and Foundry
(49) Tietjens, O. G., and Ripley, K. C., Air Resistance of High-Speed Trains and Interurban Cars
(50) Timoshenko, S., and Langer, B. F., Stresses in Railroad Track
(51) Vorlander, H. O., and Raymond, F. E., Economic Life of Equipment
(52) Weckstein, S. M., Application of Tapered Roller Bearings in Merchant-Bar Mills
(53) Wilder, Richard F., The Coordination of Research, Sales, and Production.

A.S.M.E. Annual Meeting Program

New York, November 30 to December 4, 1931

The Conference of the Local Sections' Delegates will start Sunday, November 29, at 2:00 p.m. A buffet supper will be served from 6 to 7 p.m., and group meetings will be held from 7 to 10 p.m.)

MONDAY, NOVEMBER 30

9:00 a.m. Conference of Local Sections' Delegates

9:30 a.m. Council Meeting
Processing Conference
Simultaneous Sessions:

Machine-Shop Practice and Applied Mechanics

Improved Device for Recording Instantaneous Tool Pressures in Machinability Studies, O. F. Gechter and H. R. Laird

Photoelastic Developments:

(*a*) Kinematography in Photoelasticity, Max M. Frocht
(*b*) Photoelastic Study of Shearing Stresses in Keys and Keyways, A. G. Solakian and George B. Karelitz
(*c*) Celluloid as a Medium for Photoelastic Investigation, R. H. G. Edmonds and B. T. McMinn

Materials Handling

Rustless-Steel Conveyors—Their Availability, Application, and Use, Nixon W. Elmer
Application and Design of the Floating Drive for Conveyors, N. H. Preble
Improved Material-Handling Methods in a Container Plant, H. N. Macdonald
Progress Report of Materials Handling Division

12:15 p.m. Luncheon, Council and Local Sections' Delegates

2:00 p.m. Council Meeting
Conference of Local Sections' Delegates
Simultaneous Sessions:

Applied Mechanics

Design of Spring Gears for Exhaust-Turbine Installation, J. Ormondroyd and T. C. Kuchler
Compression of Rectangular Blocks and the Bending of Beams by Non-Linear Distributions of Bending Forces, J. N. Goodier
Forced Vibrations With Non-Linear Spring Constants, J. P. DenHartog and S. J. Mikina
Progress Report of Applied Mechanics Division, A. L. Kimball

Metal Cutting

Elements of Milling, O. W. Boston and Charles E. Kraus
Tungsten Carbide and Other Hard Cutting Materials, Progress Report No. 3 of Subcommittee on Metal-Cutting Materials, Coleman Sellers, 3rd
Motion Picture: Latest Developments in German Machine Tools as Exhibited in Operation at Leipzig Trade Fair

Fluid Meters

A Study of Primary Metering Elements in 3-In. Pipe, S. R. Beitler, Paul Bucher, and T. C. Barnes, Jr.
Flow of Steam Through Square-Edged Orifices in 4-In. Line, W. W. Frymoyer and A. Herschel
Reports of Sub-Committees on Revision of Part I, Description of Flow Meters and Water Meters, and Influence of Installation

8:30 p.m. Exhibition of Art by Engineers
Concert
Public-Speaking Contest

TUESDAY, DECEMBER 1

8:50 a.m. Lecture on "Talking With an Audience," by Dr. S. Marion Tucker

9:00 a.m. Conferences of Local Sections' Delegates

9:30 a.m. Simultaneous Sessions:

Casting and Machine Design

Machine-Design Management, J. L. Alden
Correlation of Design and Foundry, Alex Taub
Progress Report of Machine-Shop Practice Division, C. deZafra

Industrial Power

Ford Motor Company's 1200-Lb. Steam-Plant Installation, A. R. Smith and H. B. Hanson
Influence of Inlet Boxes on the Performance of Induced-Draft Fans, Lionel S. Marks and E. A. Winzenburger
Characteristics of a High-Pressure Series Steam Generator, A. A. Potter, H. L. Solberg, and G. A. Hawkins
Report of Power Division

Applied Mechanics and Railroad

Air Resistance of High-Speed Trains and Interurban Cars, O. G. Tietjens and K. C. Ripley
Stresses in Railroad Track, S. Timoshenko and B. F. Langer
Report of Railroad Division (*by title*)

Lubrication Research

Optimum Conditions in Journal Bearings, Albert Kingsbury
Pressure Distribution in the Oil Films of Journal Bearings, S. A. and T. R. McKee
Oil-Film Pressures in an End-Lubricated Sleeve Bearing, Louis J. Bradford

2:00 p.m. **General**

Address by Frances Perkins on State Labor Departments and Professional Engineers—Cooperation Essential to Progress in Accident Prevention
Report of Committee on Economic Status of the Engineer
Address by John M. Carmody on Russia
Business Meeting

4:30 p.m. Towne Lecture: W. B. Donham, Dean, Graduate School of Business Administration, Harvard University, Boston, Mass.

8:30 p.m. President's Night
Business Meeting (Report of Nominating Committee)
Conferring of Honorary Membership and Other Awards
Reception and Dance

WEDNESDAY, DECEMBER 2

8:50 a.m. Lecture on "Talking With an Audience," Dr. S. Marion Tucker

9:30 a.m. Simultaneous Sessions:

Textile

The Sanforizing Process, Sanford L. Cluett
Cause and Effect of Recent Advances in Textile Machinery, E. D. Fowle
Progress Report of Textile Division (*by title*)

Fuels

Fluxing of Ashes and Slags as Related to the Slagging-Type Furnace, P. Nicholls and W. T. Reid
Report of Fuels Division

Stabilization Symposium—Jointly With A.M.A.

Business Stabilization, with addresses on financial, industrial, and economical phases
Progress Report of Management Division (*by title*)

Hydraulic (I)

Progress Report of Hydraulic Division, E. M. Breed
Hydraulic Butterfly Valves, Ross L. Mahon
Piezometer Investigation, Charles M. Allen and Leslie J. Hooper

12:15 p.m. Luncheon, Council and Student Branch Delegates

2:00 p.m. Student Branch Conference
Simultaneous Sessions:

Steam Tables

Progress Reports by L. B. Smith, F. G. Keyes, N. S. Osborne, and Harvey N. Davis

Engineering Economics—Jointly With A.M.A.

Dividend Programs Related to Depreciation, E. G. Field
Economic Life of Equipment, H. O. Vorlander and F. E. Raymond

Lubrication Engineering

Modern Oil-Lubrication Methods as Applied to Rolling-Mill Equipment, J. A. Merrill and E. M. May
Oil Requirements for Modern Rolling-Mill Circulating Systems, C. M. Larson

Hydraulic (II)

Leakage Loss and Axial Thrust in Centrifugal Pumps, Alexey J. Stepanoff
Turbulence in Centrifugal Pumps, John W. Macmeeken

6:30 p.m. Annual Dinner to New Members, Hotel Astor

THURSDAY, DECEMBER 3

8:50 a.m. Lecture on "Talking With an Audience," Dr. S. Marion Tucker

9:30 a.m. Simultaneous Sessions:

Aeronautics—Jointly With American Institute of Physics

A Study of Light Signals in Aviation and Navigation, I. Langmuir and W. F. Westendorp
Design Problems of Controllable-Pitch Propellers, W. B. Heinz
Discussion of Aeronautic Progress
Progress Report of Aeronautic Division, Elmer A. Sperry

Central Station Power

Performance of Modern Steam-Generating Units, C. F. Hirshfeld and G. U. Moran
Solubility of Calcium Salts in Boiler Water, Frederick G. Straub

Management Research—Jointly With A.M.A.

Coordination of Research and Engineering With Production and Sales, Carl L. Bausch
The Coordination of Research, Sales, and Production, Richard F. Wilder

Symposium on Steel-Mill Bearings

Straight Copper-Lead Alloys Versus Leaded Solid-Solution Bronzes for Heavy-Duty Bearings, F. R. Hensel and L. M. Tichvinsky
Millwright Bearings for Roll Necks of Medium-Sized Rolling Mills, K. W. Atwater
Water-Lubricated Soft-Rubber Bearings, W. F. Busse and W. H. Denton
Application of Celoron Bearings to Roll Necks, Arthur J. Schmitt
Application of Tapered Roller Bearings in Merchant-Bar Mills, S. M. Weckstein

12:30 p.m. Luncheon, Honorary Chairmen of Student Branches

2:00 p.m. Simultaneous Sessions:

Oil and Gas Power

Small Marine-Diesel Installations, L. B. Jackson
United States Navy Diesel-Engine Requirements, Commander Holbrook Gibson
Diesel Award
Progress Report of Oil and Gas Power Division, L. R. Ford

Education and Training

Opening Address, Roy V. Wright
Foremanship Training, U. J. Lupien
Modern Industrial Training, George Seyler

Boiler-Feedwater Studies

Determination of Carbonate, Hydroxide, and Phosphate in Boiler Waters, Progress Report of Subcommittee No. 8, W. C. Schroeder and C. H. Fellows
Foaming and Priming of Boiler Water, C. W. Foulk
The SO_4-CO_3 Ratio for the Prevention of Sulphate Boiler Scale, Everett P. Partridge, W. C. Schroeder, and R. C. Adams, Jr.

Metal Rolling

Recent Developments in Merchant-Bar Mills, G. L. Fisk
Progress Report of Iron and Steel Division, Harry A. Deuel
Foreign Supplement to Progress Report, W. Trinks

4:00 p.m. Ladies' Tea at Woman's Engineering Club

4:30 p.m. Thurston Lecture: Edward Thorndike, Professor of Education, Teachers College, Columbia University, New York, N. Y.

Evening College Reunions

FRIDAY, DECEMBER 4

9:30 a.m. Council Meeting

2:00 p.m. Council Meeting.

Synopses of A.S.M.E. Annual Meeting Papers

THESE papers, abstracts of which are published on this and the following pages, are being printed in pamphlet form for the 1931 A.S.M.E. Annual Meeting. They may be secured by filling out the blank on page 862 of this issue. Order by number, using the list given on page 852.

AERONAUTICS

Design Problems of Controllable-Pitch Propellers. By W. B. Heinz, Aeronautics and Marine Engine Department, General Electric Company, Schenectady, N. Y.

This paper presents analytical studies of the most common problems that are encountered in the design of mechanisms to rotate airplane-propeller blades about their axes. It includes: (1) a brief discussion of centrifugal thrust-bearing loads; (2) an analysis of the torque created by centrifugal force; (3) an analysis of lateral bearing loads from which their frictional torques can be determined; and (4) an investigation of the centrifugal torque of multiple masses, by means of which a counterbalance can be designed to neutralize to any desired extent, at all settings, the centrifugal blade torque. The analyses are carried further than in previous published work, and results are arrived at by which quantitative design data can be obtained with minimum numerical and graphical labor.

A Study of Light Signals in Aviation and Navigation. By I. Langmuir and W. F. Westendorp, General Electric Company, Schenectady, N. Y.

Laboratory experiments have been devised to make measurements of the visibility of light signals under conditions essentially similar to those encountered by the aviator or the navigator. Data have been collected on the direct visibility of flashing-point sources of light of different colors, flash lengths, and intervals, against different backgrounds. The time taken to locate a visible beacon was studied as a function of the beacon intensity and frequency of flashing.

The threshold candlepower required for visibility of a point source against a background is given by an empirical equation. Colored point sources were not found to be useful except in the case of red lights with background intensities above moonlight. For an airplane approaching a beacon it is advantageous to use frequencies of flashing as high as 12 to 30 per min., although with exceptionally clear atmosphere, lower frequencies may be better. In a study of the visibility of flashes of diffused light superimposed on a steady white background, white-light flashes gave the best results. A selective differential photoelectric receiver is described which detects signals of modulated diffused light of low intensity. This sensitivity is independent of the steady background brightness up to 100 times moonlight, and is from 6000 to 13,000 times as great as that of the eye in the range of background intensity from darkness up to moonlight.

The greatest difficulty in the transmission of light signals through fog is the lack of the advantages of the point source. Dense fog may increase the distances at which diffused-light signals may be detected. The range depends to a considerable extent on the reflectivity of the ground.

A theoretical treatment of the diffusion of light through fog, based on the scattering of the light rays by fog particles, indicates that airplanes can be guided through fog at distances of several miles by means of diffused modulated light acting on a differential photoelectric receiver.

APPLIED MECHANICS

Oil-Film Pressures in an End-Lubricated Sleeve Bearing. By Louis J. Bradford, Professor of Machine Design, Pennsylvania State College, State College, Pa.

Curves are shown giving the oil-film pressures found in a bearing $2^{1}/_{2}$ in. in diameter and $1^{7}/_{8}$ in. long lubricated by oil supplied to circumferential grooves at both ends of the bearing and also at one end. Clearances of 0.0005 in., 0.0043 in., and 0.0046 in. were used. It was found that no oil film could be established with the smallest clearance, that with the larger clearances conditions were unstable, but that the instability decreased as the load and clearance decreased. Evidence is given which indicates that the film is not continuous when the clearance is small and the load light. It is also shown that conditions are more stable when oil is supplied to both ends of the bearing than when supplied to one end only. Friction curves and journal running positions are given for various conditions.

Forced Vibrations With Non-Linear Spring Constants. By J. P. DenHartog and Stanley J. Mikina, Research Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

In many technical applications, couplings are used which have springs in them with an initial set. In this paper, an exact theory of the forced vibrations of a system with such a coupling is given. Conclusions concerning the shift in critical speed with the amount of initial set are drawn. The solution obtained is compared with the existing approximate solution. In an appendix the more general case of a coupling with stops is solved.

Compression of Rectangular Blocks and the Bending of Beams by Non-Linear Distributions of Bending Forces. By J. N. Goodier, Ontario Research Foundation, Toronto, Canada.

An existing method for the approximate analysis of two-dimensional stress-distribution is extended in scope and applied to two examples of some practical interest. The first is a rectangular plate or block compressed by forces applied centrally to two opposite sides, as by knife edges. Tensions of considerable magnitude are developed across the middle plane through the knife edges. These tensions are determined and illustrations given of their dependence on the extent of spreading of the load over the bearing area.

The second is intended as a quantitative example of St. Venant's principle in the bending of beams. The stresses due to a non-linear distribution of bending forces on the ends are investigated in order to estimate how far from the end one must go to find the linear distribution assumed in the elementary theory of flexure. Conclusions are given in the paper proper, and the mathematical analyses from which they are drawn are given in the appendices.

Optimum Conditions in Journal Bearings. By Albert Kingsbury, President, Kingsbury Machine Works, Philadelphia, Pa.

This paper presents in practical, serviceable form the most important results obtainable from the hydrodynamic theory of the oil film. The general theoretical treatment is supplemented by numerical evaluations whereby the conditions for the maximum load and for the minimum friction are determined for the ideal bearing. These results are reduced to apply to practical cases by means of approximate methods. Tables and graphs are given, by means of which the loads, the losses by friction, and other characteristics of specified bearing forms may be determined, and special consideration is given to the optimum conditions for more or less arbitrary bearing proportions.

Pressure Distribution in Oil Films of Journal Bearings. By S. A. McKee and T. R. McKee, respectively, Associate Mechanical Engineer and Research Associate, Bureau of Standards, Washington, D. C.

One fact which is becoming widely recognized by users of journal bearings is that under proper conditions of operation the load applied to a journal bearing is supported by the hydrostatic pressure built up in a film of lubricant wedged between and completely separating the journal and bearing. This paper describes an investigation at the Bureau of Standards, the purpose of which was to determine the distribution of pressure in the oil film of a full journal bearing for various conditions of operation and of bearing construction. A specially designed apparatus provided a means for measuring the film pressures at practically all points on the surface of a bearing when operating under different conditions of load, speed, and viscosity of the lubricant. The results of nine tests made under conditions involving changes in clearance, load, speed, and viscosity are presented graphically in the form of pressure-distribution curves.

In conclusion the characteristics of the film-pressure distribution are summarized, and further steps toward a better understanding of the pressure-distribution problem outlined.

Design of Spring Gears for Exhaust-Turbine Installation. By J. Ormondroyd and T. C. Kuchler, Experimental Division, Westinghouse Electric and Manufacturing Company, So. Philadelphia, Pa.

This paper outlines the necessity for flexibility in the coupling linkage of a turbine with a reciprocating engine driving the same shaft. A résumé of the history of the problem is given. The conditions which must be fulfilled for satisfactory operation and the details of the calculation to fulfil these conditions are discussed. For simplicity the design chosen relies on propeller damping to hold the torque oscillations within safe limits. Tests with and without flexibility in the turbine gearing are described. It is shown that the problem depends on the vibration characteristics of the system, and that a solution can be made if the drawings of the rotating parts and a few engine indicator cards at different speeds are available.

FUELS AND STEAM POWER

A Study of Primary Metering Elements in Three-Inch Pipe. By S. R. Beitler, Paul Bucher, and T. C. Barnes, Jr., respectively Assistant Professor of Mechanical Engineering, Professor of Steam Engineering, Ohio State University, Columbus, Ohio, and with Bailey Meter Company, Cleveland, Ohio.

This paper presents a portion of the results of a study of the performance of a complete series of primary metering devices in a 3-in. pipe line. The devices tested were as follows: Three types of orifices, concentric, eccentric, and segmental, with diameter ratios varying from 20 per cent to 90 per cent; flow nozzles with diameter ratios varying from 30 per cent to 88 per cent; also two venturi tubes with three throat sections each with diameter ratios varying from 33 per cent to 50 per cent. Discharge coefficients are given for these elements, using water as the metered fluid, with a wide range of differential heads. Coefficients are also given on some of the elements where superheated steam at various temperatures was the metered fluid. The effects of sharpness of orifice edge, of roughness of approach pipe, and of surface finish of flow nozzle on water coefficients are shown. The effect of temperature upon the diameter of the primary device and upon the coefficient of discharge for steam is also given. An attempt was made to gather the data in such a manner and to present the results of the study in such a way that it will be of greatest practical value.

Determination of Carbonate, Hydroxide, and Phosphate in Boiler Waters, Progress Report of Subcommittee No. 8. By W. C. Schroeder and C. H. Fellows, respectively Fellow in Boiler-Feedwater Studies, Chemical Engineering, University of Michigan, Ann Arbor, Mich., and Chemist, Research Department, The Detroit Edison Company, Detroit, Mich.

The work of Subcommittee No. 8 of the Committee on Boiler-Feedwater Studies this year has involved critical examination of the methods generally used for examining boiler water, with a view of establishing methods for plant control and referee work that later might be recommended for adoption as standard in the industry. There has been much dissatisfaction with several methods for determining certain constituents in boiler water. This is because the methods used were developed for examining other types of water and consequently are not always applicable for accurate testing of water in steam boilers.

Those methods which, in the opinion of the Subcommittee, required immediate consideration because they had to do with the determination of constituents important in control work in most plants, and because no generally accepted scheme of procedure had been found to yield satisfactory results, were: (1) Methods for the determination of alkalinity, especially that due to carbonate salts; (2) those for dissolved oxygen and carbon dioxide; and (3) those for the determination of phosphates and silicates, inasmuch as these salts influence alkalinity and, in some cases, interfere with its determination.

It was felt that the most logical way to clear up the questions arising in connection with these methods was to put the matter before a competent technician who would devote his entire time to the problem. The Subcommittee was authorized to establish a fellowship in some university to carry out the work, and one was established at the University of Michigan. The first problem taken up was methods for determining alkalinities and also some of those ions influencing alkalinity and its determination. The report tells of the progress made in carrying out this work.

Foaming and Priming of Boiler Water. By C. W. Foulk, Professor of Analytical Chemistry, The Ohio State University, Columbus, Ohio.

A rapidly increasing interest in the subject of the foaming and priming of boiler water is shown by the fact that as many papers have appeared during the last three or four years as in the preceding 20 or 30 years. New information about the behavior of suspended solids and of dissolved salts has been brought out, and a helpful theory of foam formation has also been advanced. It would be inferred from recent work that too broad generalizations in regard to foaming and priming of boiler water should not be made, because in some cases the design of the boiler profoundly affects the behavior.

Flow of Steam Through Square-Edged Orifices in a Four-Inch Line. By W. W. Frymoyer and A. Herschel, respectively Research Manager and Research Department, The Foxboro Company, Foxboro, Mass.

The data in this paper show coefficients obtained for steam flowing through square-edged orifices of d/D ratios varying from 0.42 to 0.84 installed in Foxboro recess-type flanges with connections for the differential one inch from the upstream and downstream faces of the orifice plates. The density used in the calculations was determined from the downstream pressure connection. Coefficients for various conditions are shown, such as: (*a*) Pressures varying from 40 to 150 lb. per sq. in. absolute, (*b*) differentials varying from 30 to 130 in. of water, and (*c*) various disturbance conditions.

Performance of Modern Steam-Generating Units. By C. F. Hirshfeld and G. U. Moran, respectively Chief of Research and Research Department, Detroit Edison Company, Detroit, Mich.

This paper is based on operating data collected from 244 large steam boilers over a period of three years. A preliminary paper was presented in 1929 at the annual meeting of the A.S.M.E. covering one year's records, but it was thought advisable to continue for at least two years in order to obtain more conclusive results. The primary object was to study boiler outages, with special attention given to causes, frequency, and duration, and the effect of such factors as severity of use, design, fuels, and methods of firing on boiler reliability. The authors give a general summary of the data and such discussion of results as was allowed by the short time available. It will be followed by a more complete analysis of the individual records in the near future.

Influence of Inlet Boxes on the Performance of Induced-Draft Fans. By Lionel S. Marks and E. A. Winzenburger, respectively Professor and Assistant Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.

This paper presents experimental results of tests to ascertain the effect of inlet boxes on the performance of induced-draft fans. The tests show the magnitude of the changes in performance that can be expected, and emphasize the need for testing fans with their inlet boxes attached. The conclusion drawn from the tests is that it is not sufficient for the fan user to know the characteristics of a selected fan with free inlet, but he also should know the characteristics when the inlet box is attached.

Fluxing of Ashes and Slags as Related to the Slagging-Type Furnace. By P. Nicholls and W. T. Reid, respectively Supervising Fuel Engineer and Junior Fuel Engineer, Pittsburgh Experiment Station, Bureau of Mines, Pittsburgh, Pa.

This paper is presented as a report of the Special Research Committee on the Removal of Ash as Molten Slag From Powdered-Coal Furnaces. The primary object of the investigation was to obtain data on the fluxing of coal-ash slags to enable users of slagging-type boilers to increase the fluidity of the deposited ash should it not be possible to tap at available furnace temperatures. Studies were made using a platinum-wound furnace, supplemented by a gas furnace with a 32-in. × 28-in. hearth. A standard of fluidity desirable for easy tapping was established and the results expressed as the temperature necessary to produce this fluidity, designated as the flow temperature. Values for flow temperature in terms of the chemical composition of the ash, or ash plus flux, were determined for a range of ashes found in American coals, and for additions of the following fluxes: iron ore, limestone, dolomite, fluorspar, salt cake, steel slags, and some less important minerals. It is deduced that limestone or dolomite would be the most economical material to use for slagging-type boilers as now built, and from a diagram the quantity of flux can be computed. The investigation was carried beyond present requirements for slagging-type boilers and to flow temperatures below 2400 deg. fahr. A complete diagram is given for coal ash-lime-iron showing the flow temperature plotted against composition.

The SO_4-CO_3 Ratio for the Prevention of Sulphate Boiler Scale. By Everett P. Partridge, W. C. Schroeder, and R. C. Adams, Jr., respectively Non-Metallic Minerals Experiment Station, New Brunswick, N. J., Fellow, Department of Chemical Engineering, University of Michigan, Ann Arbor, Mich., and Navy Department, Engineering Experiment Station, Annapolis, Md.

The investigation described in this paper is a logical development of R. E. Hall's well-known work. The authors felt that the true value of the SO_4-CO_3 ratio must be appreciably greater than that calculated by Hall, and, as a result, a program of research at the University of Michigan was sponsored by the Detroit Edison Company to determine more accurately, if possible, the solubility relations of boiler waters. The work done on this project is described by the authors.

Ford Motor Company's 1200-Pound Steam-Plant Installation. By A. R. Smith and H. B. Hanson, respectively Chief Engineer, Engineering and Construction Department, General Electric Company, Schenectady, N. Y., Power and Construction Department, Ford Motor Company, Dearborn, Mich.

This paper describes the general features of the 110,000-kw., 1200-lb. turbine-generator installation in the Ford plant at River Rouge. The installation is interesting from the standpoint that it has been made in an industrial power plant; that it replaces and occupies no more space than equipment which had only one-eighth its capacity; and that the change has been made without interruption of service, and with little or no exterior evidence of such a complete rehabilitation. In the time that the new equipment has been in service no operating troubles that are considered worth mentioning have developed.

Characteristics of a High-Pressure Series Steam Generator. By A. A. Potter, H. L. Solberg, and G. A. Hawkins, respectively Dean, School of Engineering; Assistant Professor of Mechanical Engineering; and Assistant Instructor, Applied Mechanics, Purdue University, Lafayette, Ind.

The steam generator consists of two parallel circuits of seamless steel tubing supplied with feedwater at one end, and delivering steam from the other end at any desired pressure up to 3500 lb. per sq. in. and at a maximum temperature of 830 deg. fahr. The changes which take place in the circuit are measured by means of thermocouples and manifolded pressure connections. The unit is controlled automatically by a system which uses the thyratron vacuum-tube circuit. A set of charts are presented which show the operation of the automatic control on a swinging load.

The tests which are reported in the paper show the effect of (*a*) varying the steaming capacity at constant pressure and temperature, (*b*) changing the pressure at constant capacity and temperature, and (*c*) increasing the steam temperature at constant capacity and two different pressures. The temperature and pressure changes through the water and steam circuit are shown graphically. Data are also presented on the heat-transfer rates through the furnace-wall tubes.

The results up to date indicate that this steam generator will operate successfully at any pressure between 1500 and 3500 lb. per sq. in. and at a maximum temperature which is limited by the materials used. Automatic control held the steam pressure and temperature nearly constant throughout the range of operation.

Solubility of Calcium Salts in Boiler Water. By Frederick G. Straub, Special Research Assistant Professor in Chemical Engineering, University of Illinois, Urbana, Ill.

The purpose of this investigation has been to determine the behavior at elevated temperatures of the various chemical compounds found in boiler waters. This includes a study of the solubility of the various compounds under conditions simulating those found in high-pressure boilers. Such a study involves the determination of the solubility of the more insoluble compounds such as calcium carbonate and calcium sulphate separately and combined, as well as in the presence of the more soluble salts such as sodium carbonate, sodium sulphate, and sodium hydroxide. These results should aid materially in determining the proper water treatment for high-pressure-boiler operation.

HYDRAULICS

Piezometer Investigation. By Charles M. Allen and Leslie J. Hooper, respectively Professor of Hydraulic Engineering and associated with Worcester Polytechnic Institute, Worcester, Mass.

This investigation had for its object the determination of a standard piezometer for commercial use and the study of the hydraulic effect of various conditions of operation upon different forms of piezometers. Piezometers were compared in operation with suitable reference orifices, the differentials being measured with hook gages. A number of factors concerning the performance of piezometer orifices were analyzed. The paper gives results covering a variety of forms and conditions, and should assist in establishing a standard form of piezometer.

Hydraulic Butterfly Valves. By Ross L. Mahon, Vice-President and General Manager, Pelton Water Wheel Company, San Francisco, Calif.

This paper describes some of the special features of design found in the modern butterfly valve, and which have been adopted within recent years during which this type of equipment has been developed to meet some of the unusual requirements existing in many modern hydroelectric projects.

Means for making this type of valve more effective in limiting leakage are discussed, and attention is given to general considerations affecting the design of disks and bodies. Some interesting types of operating mechanisms are outlined, and various kinds of protective and auxiliary equipment are described.

Recent applications of butterfly valves for free-discharge service have broadened their useful field, and the suggestion is made that valves of this type might well find future use for other purposes than those existing in the hydraulic-power industry.

Turbulence in Centrifugal Pumps. By J. W. Macmeeken, Hydraulic Engineer, Byron Jackson Company, Berkeley, Calif.

In this paper the author discusses whirlpool or vortex energy in centrifugal pumps, the harnessing of this energy for useful work, and the effect of different kinds of inequalities in vortices. It includes simple inequalities, waste energy, and synchronization of parallel vortices.

Leakage Loss and Axial Thrust in Centrifugal Pumps. By Alexey J. Stepanoff, Draftsman, Byron Jackson Pump Manufacturing Company, San Francisco, Calif.

This is a report on experiments performed at the hydraulic laboratory of the University of California with the equipment furnished by the Byron Jackson Company, of Berkeley, Calif. Factors governing leakage loss and means to reduce it were studied. Leakage was measured with a special pump under actual operating conditions, using wearing rings of various types, widths, and clearances. Tests were performed at four speeds and different heads. The results are presented in the form of curves, the coefficients of discharge through the clearances being plotted as ordinates against pressures at the wearing ring as abscissas. To facilitate the calculation of the pressure at the wearing ring the pressure distribution in the pump case was studied and an approximate formula developed.

The axial thrust in single-stage and multi-stage pumps was measured with a specially designed thrust bearing which indicated the thrust directly in pounds under actual operating conditions. New sources of thrust were established: those caused by unequal pressures on the impeller shrouds from the inside due to various causes, the most important of which are an uneven radial-velocity distribution and cavitation.

In multi-stage pumps with impellers mounted back to back, generally considered balanced on account of symmetry, it was discovered that there is considerable axial thrust produced by unequal pressures in adjacent stages acting upon the shaft shoulders and impeller hubs extending through the walls of the adjacent stages. Means to eliminate this thrust were found.

IRON AND STEEL

Millwright Bearings for Roll Necks of Medium-Sized Rolling Mills. By K. W. Atwater, H. A. Brassert and Company, Chicago, Ill.

The performance of metal roll-neck bearings is frequently unsatisfactory, particularly with regard to rapidity of wear and excessive power loss in friction. Roller bearings, although free from these disadvantages, are comparatively expensive and are limited in applicability because of their space requirements. These circumstances provide a definite field of usefulness for bearings made of very hard wood.

Tests of various species of lignum-vitae, and of different methods of cutting bearings from the log, have indicated specifications under which satisfactory lignum-vitae bearings can be produced. Bearings produced according to these specifications, are used successfully in a great many rolling mills.

Lignum-vitae bearings can be lubricated adequately by means of water sprays. With such lubrication, the rate of wear and the power loss in friction of these bearings are considerably lower than those of metal bearings lubricated with oil or grease. In some rolling mills, the use of lignum-vitae bearings has effected power savings as high as 23 per cent, in comparison with bearings made of metal.

Tests have also shown that the life of lignum-vitae bearings in certain cases was 15 times as long as that of metal bearings. Experience has indicated that the best results with such bearings can be obtained by polishing the roll necks before installation in the mill.

Water-Lubricated Soft-Rubber Bearings. By W. F. Busse and W. H. Denton, respectively Physicist and Junior Physicist, Physical Research Laboratory, B. F. Goodrich Company, Akron, Ohio.

Rubber bearings lubricated with water are found to give excellent service under many conditions. The softness of the rubber makes them stand up in the presence of sand and grit, and it also makes the laws of lubrication governing them differ from the classical laws worked out by Reynolds and others for cylindrical metal bearings.

This paper gives a comparison of the friction of rubber and metal bearings lubricated with water at various loads and speeds. Metal bearings have the lower static coefficients of friction, but the coefficient of running friction is usually lower for the rubber bearing. The difference in favor of the rubber bearing increases as the load increases, provided the shaft is smooth and the load is applied after the shaft gets up to speed. Rubber bearings have been used at loads up to 850 lb. per sq. in.

Rubber bearings are particularly suitable for use on shafts running at high speeds not only because the friction is very low, but because the softness of the rubber allows the shaft to turn on its center of gyration, even though this differs slightly from the geometrical center, thus reducing the dynamic load in the bearing and the vibration in the machine.

Recent Developments in Merchant-Bar Mills. By G. L. Fisk, Consulting Engineer, Mesta Machine Company, Pittsburgh, Pa.

After first discussing trade demands on merchant-mill products, the author points out the value of research and records in the making and rolling of steel. He then proceeds to discuss the factors affecting the quality of product in the merchant mill, and the items to be considered when selecting the type of merchant mill for a given range of products in a given plant. He next takes up the use and arrangement of vertical mills, and the application of roller bearings to mill rolls in the case of existing and new mills, discussing also the economic and practical considerations involved. He then gives particulars of a new transfer-table design, and points out the uses and advantages of electric-driven flying shears. Finally, cooling-bed requirements to meet the needs of various merchant-mill products are considered, as well as cooling-bed design and operation, objections to the double cooling bed, and double cold shearing from a single bed.

Straight Copper-Lead Alloys Versus Leaded Solid-Solution Bronzes for Heavy-Duty Bearings. By F. R. Hensel and L. M. Tichvinsky, Research Laboratories, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

This paper describes the metallurgical investigation of various bronze bearing metals, and deals with a comparative study of the bearing performance of those metals. The technological possibilities of producing heavy-duty bearings were investigated. Experimental installations of bearings with severe requirements are under trial.

Application of Celoron Bearings to Roll Necks. By Arthur J. Schmitt, Continental-Diamond Fibre Company, Cleveland, Ohio.

Celoron is a synthetic substance manufactured by subjecting layers of canvas, previously impregnated with resin, to extreme heat and high pressure. This process converts the canvas and resin into a hard, tough, dense, and resilient material. Celoron is usually molded to the required shape, but can be machined easily when necessary. The suitability of celoron for roll-neck bearings has led to widespread use of the product in that field.

The resilience of celoron bearings allows them to absorb severe impact loads without permanent deformation. These bearings can be designed, however, so that, in spite of their resilience, their elastic deformation under load is not sufficient to produce undue variations in thickness of the rolled products. Celoron bearings are most commonly lubricated with water, in which case the rate of wear and the power consumed in friction are much less than those of metal bearings. Although excellent service can be obtained from celoron bearings lubricated with water, the application of a superior lubricant such as oil or grease to these bearings improves their performance appreciably. Celoron bearings serve most efficiently on highly polished roll necks.

Celoron bearings are in use in a wide variety of rolling mills, where they sustain loads varying from 1000 to more than 2500 lb. per sq. in. of projected bearing area. They have produced substantial power savings in comparison with metal bearings. The life of celoron bearings in numerous installations has been found to be many times that of metal bearings. In many cases the number of off-gage rejections has been reduced materially by the use of these bearings.

The fact is emphasized that celoron bearings are particularly suitable for use under adverse conditions, such as those which exist in many rolling mills, where inadequate lubrication or excessive scale and grit make the long-continued operation of bearings very difficult.

Application of Tapered Roller Bearings in Merchant-Bar Mills. By S. M. Weckstein, Industrial Equipment Engineer, Timken Roller Bearing Company, Canton, Ohio.

Tapered roller bearings have played an important part in the numerous developments in the art of rolling metals. Their use has made possible a considerable decrease in the consumption of power by the elimination of friction; a considerable decrease in the cost of the electrical equipment required; a decrease in the cost of lubrication and general maintenance; an increase in the speeds of operation and consequently in the tonnage produced; and a marked increase in the accuracy of the product.

In this paper the actual experience over a period of five years in the proper design, mounting, and operation of bearings in merchant-bar mills is discussed. Extracts are given from the results of a series of power tests made on the same mills alternately equipped with plain and tapered roller bearings. Various means of lubrication of rolling mills, pinion stands, and gear drives are cited. The design of suitable bearing closures is also taken up and shown in detail. The illustrations shown are of equipment in actual operation in various mills.

MACHINE-SHOP PRACTICE

Machine-Design Management. By J. L. Alden, Assistant Superintendent of Manufacturing Development, Western Electric Company, Inc., Chicago, Ill.

Existing literature does not cover the field of management of machine-design organizations adequately. This paper outlines desirable management practices, and describes the methods and systems used to control the machine-design organization at the Hawthorne plant of the Western Electric Company.

Elements of Milling. By O. W. Boston and Charles E. Kraus, respectively, Professor and Student, College of Engineering, University of Michigan, Ann Arbor, Mich.

This paper presents the results of laboratory milling tests on a variety of materials, using a pendulum-actuated, single-tooth milling dynamometer. Tools of various widths having front-rake angles of 15 deg., but no side-rake or helix angles, were used. Tests were run both dry and with a number of cutting fluids. Except where deliberately allowed to dull, the cutters were considered sharp at all times.

The cutting was done with the cutter rotating in a plane perpendicular to the surface of the work, and in all cases data for two fundamental methods of cutting are shown; first, milling up in the regular way with the work being fed into the cutter, and second, milling down with the work fed with the cutter. In nearly every case a difference in energy is found between these two methods of cutting.

Data giving the energy in foot-pounds necessary to remove a single chip are shown for 13 widely different materials with constant feed and various values of depth, and then with constant depth and various values of feed. Several different cutting fluids were used. These data are plotted and energy equations are derived for each material. Values of the constants are given. Corresponding formulas and values for the horsepower per cubic inch per minute are also given. No two materials give the same values of the exponents for the feed and depth variables.

Data are also shown for milling with the cutter in the sharp, dull, and very dull conditions, to determine the effect of the sharpness of the tool on the milling-energy formulas. It is found that dulling does change the formula, but has greater effect on feed than on depth of cut.

Tests were run on four materials using 11 different cutting fluids to determine the effect of cutting fluids on milling energy. It is concluded from the nature of the tests that lubrication rather than cooling has the greater effect. The data show a different order for the fluids for each material, but in nearly all cases a power saving is made by their use.

Milling-energy data are also presented for a large variety of materials when the cut was held constant at 0.125 in. depth, 0.010 in. feed, and the cutter was 0.250 in. wide and had a 15-deg. front-rake angle, in order to compare these materials from a milling-energy standpoint. It is concluded that there is no way, other than actual test, to determine the milling properties of a material.

A discussion of previous milling papers has been added and an analysis of the form of a milling chip is presented. It is concluded from this analysis that, theoretically, the coarse-tooth cutter is better than the fine-tooth cutter, when milling up, keeping the linear feed per tooth constant. When milling down, however, the fine-tooth cutter removes a chip of greater average thickness than the coarse-tooth cutter, and consequently is considered to be more efficient from a power standpoint when diameter and feed per tooth are constant.

The fine-tooth cutter, cutting down, produces the greatest average thickness of chip of all combinations and is thought to be the most efficient way of milling metal when power is the chief consideration. It is shown that the average thickness of chip when both feed and depth of cut are varied is not a satisfactory basis for an energy equation.

Celluloid as a Medium for Photoelastic Investigation. By R. H. G. Edmonds and B. T. McMinn, Assistant Professors of Mechanical Engineering, University of Washington, Seattle, Wash.

This paper deals with the physical properties of celluloid and their bearing on its use in the photoelastic method of stress determination. The authors present curves and test data on American-made celluloid, showing stress-strain and time-creep relations. Their results indicate that the physical constants for this material are not fixed, but have a consistent variation with speed of loading. Their work shows that celluloid is not properly elastic under any condition of loading. They point out some important peculiarities in the interrelation between photoelastic color and stress and strain.

Kinematography in Photoelasticity. By Max M. Frocht, Associate Professor of Mechanics, Carnegie Institute of Technology, Pittsburgh, Pa.

Photoelasticity is one of several methods for stress analysis. Kinematography in photoelasticity was made practicable by the introduction of the monochromatic method, and should be found useful in the study of gear action, tool cutting, impact stresses, and the phenomenon of failure. Moving pictures of 15 models in 29 set-ups are presented which show a variety of stress-distribution patterns and their formations. Stress concentration can spring from various sources such as holes, grooves, notches, sharp curves, scratches, and the edges of flat steel dies.

A layer of rubber, lead, or wood has been found to eliminate stress concentration due to the die and self-destruction of stress concentrations when the sources are many and close. Application of this principle is made to the design of a thread, and results from direct tests are shown which substantiate it.

Moving pictures are presented showing the stress fluctuation during impact, and from these the increase of stress in pure bending and the time of oscillation are determined, the latter being in good agreement with theory.

Improved Device for Recording Instantaneous Tool Pressures in Machinability Studies. By O. F. Gechter and H. R. Laird, Western Electric Company, Chicago, Ill.

A device is described in this paper which permits the measurement of the three tool-pressure components during the machining of short test pieces. The advantages of the device as compared with similar devices used in the past are outlined. It is shown that the use of the piezoelectric pressure-measuring method makes possible a rigid tool mounting and the recording of relatively sudden pressure changes. The mechanical and electrical limitations are discussed and improvements are suggested. A discussion of some of the test results illustrates the value of the device for machinability studies.

Photoelastic Study of Shearing Stresses in Keys and Keyways. By Arshag G. Solakian and George B. Karelitz, Columbia University, Department of Mechanical Engineering, New York, N. Y.

The technique of photoelastic determination of stresses in structural members, using Bakelite as the transparent medium, is described. The mechanical properties of this material and the process of annealing it for the removal of the internal stresses are given. The shearing stresses in keys and keyways are investigated. It is shown that it is desirable to round the corners of the keyway, with a corresponding chamfering of the key. The use of color fringes, called "isochromatics," for the determination of shearing stresses has been found very helpful and is highly recommended.

Correlation of Design and Foundry. By Alex Taub, Research Engineer, Chevrolet Motor Company, Detroit, Mich.

Correlation of design to foundry is a necessary part of any sound engineering program; however, it is quite often neglected, which adversely affects the ratio of the result per dollar. In considering the foundry, the fact that individual foundry practices vary must be borne in mind.

Castings are virtually assembled in the liquid state within the mold, and this principle must be kept in mind, but not overemphasized. Open-mindedness on the part of the designer is essential. Foundrymen must be urged to express new foundry ideas, since in new designs provision might be made to permit the use of new foundry development.

Machine-made green-sand coring is a new practice being successfully used. The true bulk of a design as far as the foundry is concerned is in the flask, not in the individual casting. Wall thickness is a general target on weight reduction. This is bad practice and should be avoided. Weight must be eliminated by design. The designer can help in obtaining clean castings by providing ample space for cores.

Driers are a necessary evil, and the design should be such as to eliminate them whenever possible. Driers interfere with the mobility for change which has become an industrial necessity. Elimination of fins from castings still requires development on the part of the foundry. A large proportion of foundry and engine operation difficulties can be traced to improper determination of engine length, quite often by a non-technical executive.

Impatience on the part of engineers to see their designs in operation results in insufficient time for the foundry to gain necessary experience with experimental castings. Cost items accrued during productive periods should be investigated and eliminated from any new design. Elimination of foundry difficulties also means elimination of trouble to the ultimate owner. Therefore the foundryman and engineer are equally interested in the final result.

Tungsten Carbide and Other Hard Cutting Materials. Progress Report No. 3 of Subcommittee on Metal-Cutting Materials of the A.S.M.E. Special Research Committee on the Cutting of Metals. By Coleman Sellers, 3rd, Superintendent, Engineering Department, William Sellers & Company, Inc., Philadelphia, Pa.

Shortly after this Subcommittee's progress report No. 2 in June, 1930, the activities were broadened to include not only tungsten carbide but other hard cutting materials. In April, 1931, a second questionnaire was sent out to the leading manufacturing establishments of the country with a letter asking that all those that had experience with tungsten and tantalum carbide or other new alloys, answer the questions as far as possible. It was thought that the information thus obtained might help to determine the present status of the use of these materials, and perhaps lead to the enlightenment of some as to their possibilities and limitations.

This questionnaire was sent out thirteen months after the first one. It is interesting to note that the answers show that considerable progress has been made, not only in the number of users, but that many of those that used a little have found it worth while to extend the use. Furthermore much has been learned in the methods of use. Over 100 replies were received, of which 85 gave the information on which this report is based.

MANAGEMENT

COORDINATION OF RESEARCH AND ENGINEERING WITH PRODUCTION AND SALES. By Carl L. Bausch, Manager of Research and Engineering, Bausch & Lomb Optical Company, Rochester, N. Y.

This paper is largely an exposition of the organization of the Bausch & Lomb Optical Company, Rochester, New York, in so far as it effects the function of research and engineering. This company went through a thorough reorganization several years ago and was fortunate in being of sufficient size to justify a distinct research and engineering division, and still small enough to make it possible to tie the functioning of these departments to that of the other departments without getting involved in too much machinery and red tape. The company has about 3000 employees, and a research and engineering force of about 100. It manufactures a very large variety of small-quantity production items, although there are a few items that are manufactured on what might be considered a quantity-production basis. Although it has naturally tried to minimize the amount of development work on articles that are expected to be sold in small quantities, still experience shows that quantity can have no great influence on the thoroughness with which the development work must be done, the company being often forced by circumstances to spend large amounts on work which will never result in large production.

The head of the research and engineering department reports directly to the general manager and assumes full responsibility for all expenditures for development work.

A yardstick has been set up by which accomplishments can be measured. This yardstick is the relationship between money spent on development work and the value of new business created, which consists of the amount of work of a regular production nature placed in the plant for manufacture, plus all special customers' orders requiring engineering-department design and follow-up. Figures are shown of this ratio for different classes of product.

Although the research and engineering division assumes full responsibility for development work, sales and production are very definitely tied into it and must assume part of the responsibility when manufacture is finally started. Effective means are used to bring this condition about.

DIVIDEND PROGRAMS RELATED TO DEPRECIATION. By E. G. Field, Cost Consultant and Industrial Engineer, William H. James and Associates, Atlanta, Ga.

Figures are presented to show the working out of five selected dividend programs and to demonstrate that depreciation funds can be and often are misused as a result of the program chosen. Several related subjects are also discussed such as historical statements for interpretation of results, possibility of a current investment to current liability ratio, dividends that return parts of the original investment, and depreciation funds spent by management.

FOREMANSHIP TRAINING. By U. J. Lupien, Assistant Manager, Industrial Relations Division, Cheney Brothers, South Manchester, Conn.

This paper tells of the early development of programs of foremanship training and some of the reasons for the growth of the movement. The author does not present this method as the only one that should be applied, but gives the plan with which he is most familiar, based on an experience of years as a supervisor of labor and as an executive in charge of foremen and learners, and as a leader of foremen training courses. The development of the program is based on the supposition that the foreman has a definite place in industry, even though functional control has attempted to relieve him of some of his responsibilities, and that industry is realizing the necessity of taking the foreman into the confidence of management in the development and alteration of policies that directly affect the industrial-relations aspects of the company.

ECONOMIC LIFE OF EQUIPMENT. By H. O. Vorlander and F. E. Raymond, respectively Research Assistant and Associate Professor of Industrial Research, Department Business and Engineering Administration, Massachusetts Institute of Technology, Cambridge, Mass.

The correct solution of the problems of how to select and when to replace equipment is vital to industry. In fact, it revolves about the larger problem of how to invest economically and profitably the capital resources of any enterprise. Many rule-of-thumb as well as a number of somewhat more exact methods are now being employed as a basis for determining equipment policies; however, no one of these methods is suitably adapted to the present needs of industrial executives, process engineers, plant managers, and sales executives. Accordingly the A.S.M.E. sponsored a research project to investigate thoroughly this subject and formulate the principles upon which any equipment policy should be based, and out of which practical technique can be evolved for the ordinary purposes of industry. As a result, this paper, which constitutes the formal report on the project, presents criteria for the economic or useful life of equipment, for the determination of depreciation policies, for the ultimate ability of equipment to produce earnings or profits for protection from the hazard of impending obsolescence, and for the guidance of equipment manufacturers in the evolution of new designs and in anticipating the needs of industry. All of these criteria depend upon the relative economic superiority of some proposed type of equipment over some equivalent existing type or one chosen as a standard of comparison, and the evaluation of each can be achieved through formulas which are equally applicable to machine tools, jigs and fixtures, labor-saving or material-handling devices, process and power equipment, and even buildings or structures. Moreover in the course of the investigations many other important facts were discovered which relate to financial policies, accounting practice, the origin and proper methods of treating overhead, plant layout, maintenance, productivity and idle time, salvage and resale policies, machine design, and, in general, the earning power of the enterprise; all of which are discussed in detail.

MODERN INDUSTRIAL TRAINING. By George A. Seyler, Works Manager, Lunkenheimer Company, Cincinnati, Ohio.

In this paper the author gives results that will ensue from a proper program of training of supervisors for industrial plants. Industry, he states, can expect definite and satisfactory results from proper training efforts.

COORDINATION OF RESEARCH, SALES, AND PRODUCTION. By Richard F. Wilder, Research Assistant in Department of Business and Engineering Administration, Massachusetts Institute of Technology, Cambridge, Mass.

This paper seeks to demonstrate how the various research activities are coordinated one with another, and then as a unit with sales and production, so as to consider related factors in the instigation and carrying forward of research projects. Likewise it aims to bring out how definite mechanisms of coordination may be established whereby the greatest benefits may be derived from the research activities through the development and manufacture of products which are both commercially and technically sound.

MATERIALS HANDLING

RUSTLESS-STEEL CONVEYORS—THEIR AVAILABILITY, APPLICATION, AND USE. By Nixon W. Elmer.

This paper covers corrosion-resistant metals for material-handling use, giving tables of relative corrosion resistance and costs under reasonably average conditions, particularly where food products are concerned. The various available materials are briefly described and their good and bad features and qualities developed. The types of conveyors for which these materials have been used are described, and the important and characteristic installation features of each discussed.

IMPROVED MATERIAL-HANDLING METHODS IN A CONTAINER PLANT. By H. N. Macdonald, Vice-President, The Sherman Corporation, New York, N. Y.

The reorganization of materials handling at the Philadelphia plant of the Container Corporation of America, discussed in this paper, was selected by the Materials-Handling Division of the A.S.M.E. for its progress report because of the very interesting and involved problems which it was necessary to overcome to reduce materials-handling costs and increase storage areas.

The far-reaching and vital effect which materials-handling methods and controls have on the layout and systematic planning of all paper-mill operations is recognized by capable executives and is a constant problem encountered by members of the engineering profession whose work requires contact with the paper industry. When cognizance is given to the fact that over 500 tons of raw materials are consumed each day in this plant, the amount of handling involved to maintain a constant and uninterrupted flow of material to the productive machines is obvious.

The successful conclusion of this engineering work was due to the patience and care applied to each problem, and also to the fact that each improvement and change in procedure was designed or developed to fit the individual process or operation. Here again is a case where the unbiased engineering viewpoint plus experience accomplished objectives that were practically impossible under any other method.

Application and Design of the Floating Drive for Conveyors. By N. H. Preble, Engineer, Jervis B. Webb Co., Detroit, Mich.

Increasing demand for longer conveyors and conveyors more heavily loaded per foot of length has brought about the necessity of using multiple drives on a single strand of conveyor chain in order to keep the weight and cost of chain and carrier units down to a reasonable point. To meet this requirement there has been developed a floating type of driving mechanism, so arranged that two or more drives located at considerable distances from each other will automatically synchronize as to speed and thus maintain proper driving action at each drive point. The paper describes in detail the development of this design and its application to various types of conveyors, pointing out the advantages obtained through its use not only as a synchronizing means, but also in properly distributing the total load, in effecting smoother operation, in replacement of the standard form of shear pin, etc. Applications are described not only to the overhead-trolley conveyor, but also to other types of double- and single-strand construction with both caterpillar and sprocket drives.

OIL AND GAS POWER

United States Navy Diesel-Engine Requirements. By Holbrook Gibson, Commander, Bureau of Engineering, Navy Department, Washington, D. C.

Most of the Diesel-engine activities of the U. S. Navy are confined to the submarine, which must be driven by internal-combustion engines. The paper outlines the development of the internal-combustion engine for submarine use and points out the effect that the London Treaty has had on design. Causes for unreliable performance of Diesel engines are given, and methods for overcoming them are discussed. From a careful survey of the Diesel-engine field the Bureau of Engineering has concluded that modern Diesel engines for naval use must be of the light-weight high-speed design.

Small Marine-Diesel Installations. By L. B. Jackson, Manager, Marine Diesel Sales, Fairbanks Morse & Company, Chicago, Ill.

In this paper the author discusses the Lemp system of drive, which can be considered as a combination of direct drive with Diesel-electric drive. Its scope includes propelling and auxiliary equipment for marine-Diesel installations in which the Diesel unit does not exceed 1200 b.hp.

PETROLEUM

Modern Oil-Lubrication Methods as Applied to Rolling-Mill Equipment. By Joseph A. Merrill and Edwin M. May, District Managers at Chicago and New York, respectively, for S. F. Bowser and Company, Inc., Fort Wayne, Ind.

In this paper the authors trace the improvement made in lubrication methods for rolling-mill machinery from early times up to the present. The increase in size, speed, and capacity of continuous rolling mills made necessary the use of heavier oils. The modern heavy-oil filtering system is described, and common practice in the selection of oils for various types of equipment is indicated. Modern oil systems of lubrication give maximum safety and protection against involuntary shutdowns, and this is the reason that modern heavy-oil filtering systems are in such general use.

Oil Requirements for Modern Rolling-Mill Circulating Systems. By C. M. Larson, Supervising Engineer, Sinclair Refining Company, New York, N. Y.

Oil for modern oil-circulating systems should allow ample circulation over a wide range of temperatures, should have stability, and should maintain an adequate lubricating film under heavy loads. Each of these three essentials is taken up in the paper, and oils that have the necessary characteristics are discussed. Results obtained by the Navy endurance test have been most satisfactory, and this appears to give more reliable results than any other single service test. Information on oil-film strengths is given.

RAILROAD

Air Resistance of High-Speed Trains and Interurban Cars. By O. G. Tietjens and K. C. Ripley, Research Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

A study is made of the economies possible by reducing air resistance of high-speed passenger trains and interurban cars, and a critical survey is given of the train-resistance formulas as used hitherto and the various methods of determining the coefficients of these formulas. It is shown that the general ideas on which the train-resistance formulas are based have to be corrected according to the more modern aerodynamic conceptions on air resistance.

Data on air resistance of train models of various shapes recently obtained in the Westinghouse wind tunnel are given in a number of curves. The method applied and the experiment set-up are fully described. It is shown that a considerable reduction of air resistance of present-type trains and interurban cars can be obtained by streamlining.

The fundamental laws on air resistance are given, and it is pointed out on what air resistance mainly depends. The importance of the critical Reynolds number is explained, particularly in connection with the reliability of model tests. A number of striking examples are given showing that the air resistance of a body can be reduced by streamlining to $^1/_{20}$ of its original value. A more rational method of determining the total resistance of trains and interurban cars is given.

Stresses in Railroad Track. By S. Timoshenko and B. F. Langer, respectively Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich., and Mechanics Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

With the constant tendency in railroad practice to increase the axle loading and the speed of locomotives, the problem of stresses produced in rails by moving loads becomes more and more important. During the last 15 years, an important piece of work in this field has been done by the Special Committee on Stresses in Railroad Track under the direction of Prof. A. N. Talbot. In this work a complete theory for the bending of rails produced by vertical loads has been developed, as well as an experimental method for determining these loads.

Further progress in the determination of track stresses was made by engineers of the Westinghouse Electric and Manufacturing Company, principally in connection with the study of the tracking characteristics of electric locomotives. There has been developed in this study a method for experimental determination, not only of vertical but also of lateral forces produced on the rails by a moving locomotive, and it is shown that these lateral forces produce in rails very high stresses.

In this paper a brief discussion of the theory which has been used as a guide in this experimental research work is given, and some recent experiments in the laboratory and in the field are described. Special attention is given to the local stresses in rails produced by vertical and lateral forces. It seems that this is the first time that these stresses have been studied. The importance of knowledge of these stresses for a logical design of rail profiles cannot be overestimated.

TEXTILE

The Sanforizing Process. By Sanford L. Cluett, Vice-President, Cluett, Peabody and Company, Inc., Troy, N. Y.

The process and mechanism described in this paper were designed primarily to treat a fabric so that its dimensions will remain substantially unchanged when the fabric is subjected to a laundry washing or other cleaning process. The principal reasons for the shrinkage of finished textile fabrics when laundered are given, and the "Sanforizing" process for preventing shrinkage is described. Data are included on several actual characteristic runs of different fabrics.

Cause and Effect of Recent Advances in Textile Machinery. By Edwin D. Fowle, Associate Editor, *Textile World*, New York, N. Y.

There is an important general advance in the improvement of textile machinery. The cause lies mainly in the necessity which the machinery manufacturers faced of developing equipment for replacement rather than for expansion. A slight falling off in the rate of development began this year, due largely to the great expense which the work entails, but the rate is still far above normal. If the industry will refrain from employing high-production machines to increase total output, that is to say, if it will use such equipment strictly to decrease operating costs, it will have a splendid opportunity to eliminate or reduce the overproduction which now hampers it. This is because continual renovation of the better mills will close the less efficient ones, and because reduced costs, followed by reduced selling prices, will widen the market.

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AIR PREHEATING

Economic Aspects. Economic Aspects of Air Preheating, C. S. Darling. Power Engr., vol. 26, no. 306, Sept. 1931, pp. 325–327. True value of preheated air intermeshed with importance of other boiler-room costs; subdivision of heating surfaces feature of modern practice; charges on recovery of energy; component of boiler-room charges; potential value of preheated air; increased furnace temperature, major advantage of preheat; maintenance of high-temperature air in ducts; temperature of air ducts; corollary to insulation of air ducts.

AIR COMPRESSORS

Diesel-Driven. A New Oil Engine Compressor Unit. Engineer, vol. 152, no. 3942, July 31, 1931, pp. 124–126, 14 figs. Robeys, Ltd., of Lincoln, have put on market range of oil engine-driven compressors of straight-line type; working parts are completely enclosed and carried upon baseplate which is common to both engine and compressor engine is similar in design to Robey's ordinary horizontal type; it has stroke of 20 in. and bore of $10\frac{1}{2}$ in., and runs at 270 r.p.m.

AIRPLANE ENGINES

Design. Air-Cooled Cylinder-Head Design, R. Chilton. Soc. Automotive Engrs.—Jl., vol. 29, no. 3, Sept. 1931, pp. 185–189, and (discussion) 189–191 and 227, 1 fig. Major requirements for good cooling of air-cooled cylinder-head are: adequate conductivity from zones of maximum heat-flow, that is, spark-plug bosses and exhaust-valve seats, elbows and guides, to sufficient area of finning, and maintenance of high-velocity air-flow over entire length and depth of all fins; cylinder-head temperatures as basic indication of safe engine-operation.

Diesel. Compression-Ignition Engines, H. T. Tizard. Aircraft Eng., vol. 3, no. 30, Aug. 1931, pp. 185–186 and 196, 2 figs. Theoretical comparison with gasoline engine with particular regard to thermodynamic aspects; effect of initial temperature; limiting efficiencies; possibilities of supercharging; two-stroke operation.

Hispano-Suiza. Hispano-Suiza 1000 Hp. 18 Cylinder Stock Aircraft Engine Is Designed After 1929 Schneider Cup Race Entry. Automotive Industries, vol. 65, no. 7, Aug. 15, 1931, pp. 242–244, 5 figs. Features of engine developing 1125 b.hp. at 2000 r.p.m. with 5.91 by 6.70 in. bore and stroke; weight of engine 1188 lb.

Testing. An Aero-Engine Testing Plant. Engineer, vol. 152, no. 3944, Aug. 14, 1931, p. 177, 1 fig. New plant installed at works at New Malden, of British Salmson Aero Engines, Ltd., by Heenan and Froude; intended for testing radial engines of from 40 up to 250 b.hp.; it follows usual Froude design, in which power developed by engine is absorbed and measured by hydraulic brake, while engine cylinders are kept cool by artificial draft produced by fan driven by separate motor.

AIRPLANES

Autogiros. See AUTOGIROS.

Brakes. Experiments With Airplane Brakes, F. Michael. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 646, Sept. 1931, 28 pp., 40 figs. on supp. plates. Rolling and landing tests for determining characteristics of pneumatic brakes, with particular regard to servo effect; tables give braking torque for different brake linings; comparison of results with automobile practice. Translated article from **Zeit.** fuer Flugtechnik und Motorluftschiffahrt, May 28, 1931, previously indexed.

Fuels—Vapor Lock. Airplane Fuel-Line Temperatures, O. C. Bridgeman, C. A. Ross, and H. S. White. Soc. Automotive Engrs.—Jl., vol. 29, no. 2, Aug. 1931, pp. 121–125, 7 figs. Temperatures were measured at various points in fuel systems of airplanes of five types under variety of flight conditions; three types of vapor lock in airplanes and two remedies dealing with fuel-system design; tests of Bureau of Standards.

Rating. An Efficiency Formula for Cargo Airplanes, G. A. Rathert. Soc. Automotive Engrs.—Jl., vol. 29, no. 3, Sept. 1931, pp. 241–242 and (discussion) 242 and 252. Merit rating equals speed times payload/horsepower in pound-miles per hp-hr.; average data of load-carrying ability of more than 200 airplanes by groups and types.

Tailless. The Pterodactyl Aeroplane. Engineering, vol. 132, no. 3420, July 31, 1931, p. 152, 1 fig. Westland Hill Pterodactyl Mark IV is tailless monoplane provided with three-seater cabin, and power plant consists of De Havilland Gipsy III engine, driving pusher airscrew; object of design is to obtain higher degree of safety, comfort and performance than is possible with aircraft of normal form.

Wings—Fuselage Effect. Fuselage Interference Effect, A. S. Hartshorn. Aircraft Eng., vol. 3, no. 30, Aug. 1931, pp. 201–203, 2 figs. Interpretation of available test data points to conclusions favorable to high wing in monoplanes.

Wings—Variable Surface. L'aile Gérin à surface variable (Gérin Wings With Variable Surface). Aéronautique, vol. 13, no. 144, May 1931, pp. 188–189, 7 figs. Design of wing with mechanism permitting threefold enlargement of surface.

AIRSHIPS

Military ("Akron"). The United States Rigid Airship "Akron." Engineering, vol. 132, no. 3423, Aug. 21, 1931, pp. 215–218, 8 figs. partly on p. 230. First of two airships intended for service with United States Navy; they will be largest in existence, having cubic content approximately twice that of "Graf Zeppelin;" built on triple-layer principle of Zeppelin-type airships; helium is used instead of hydrogen to obtain necessary lift; provision is made for storage of five completely assembled airplanes; particulars of "Akron" hangar; building is primarily factory for construction of airships, equipped with numerous mechanical-handling devices.

ALLOY STEELS

Cold Treatment. The Cold Treatment of Certain Alloy Steels, G. V. Luerssen and O. V. Greene. Am. Soc. Steel Treating—Preprint, no. 24, for mtg. Sept. 21–25, 1931, 45 pp., 37 figs. Existence of certain alloys of "border-line" type between so-called austenitic and martensitic or peralitic steels which can be appreciably hardened by cooling to low temperatures; studies on several alloys including two chromium-nickel steels and two nickel-silicon steels, which are investigated in detail, and physical properties determined after such treatment.

Heat-Resisting. Die an hitzebestaendige metallische Werkstoffe zu stellenden Anforderungen und ihre Pruefung (Requirements and Testing of Heat-Resisting Metals), O. Hengstenberg and F. Bornefeld. Kruppsche Monatshefte, vol. 12, June 1931, pp. 153–158, 3 figs. Requirements of alloys subjected to high temperatures; testing methods. Bibliography.

Heat-Resisting Steels, H. N. Bassett. Indus. Chemist, vol. 7, no. 79, Aug. 1931, pp. 318–319. Requirements of heat-resisting steels; corrosion-resisting steels of high chromium content are heat-resisting to some extent; addition of vanadium further improves steel; addition of silicon reduces air-hardening effect of carbon-chromium combination and raises critical range; when silicon is high, proportion of chromium may be reduced and steel will still possess fair resistance to oxidation; industrial applications.

Steam Effect. Endurance Properties of Some Well-Known Steels in Steam, T. S. Fuller. Am. Soc. Steel Treating—Preprint, no. 8, for mtg. Sept. 21–25, 1931, 16 pp., 13 figs. Endurance properties of nickel steel, non-corrodible chrome-iron alloys, several nitriding steels, and austenitic steel of 18 per cent chromium-8 per cent nickel type have been determined in air and in steam under various conditions of temperature and pressure.

ALLOYS

Brass. See BRASS.

Bronze. See BRONZE.

Copper-Nickel. See COPPER-NICKEL ALLOYS.

Iron-Carbon. See IRON-CARBON ALLOYS.

Lead. See LEAD ALLOYS.

X-Ray Analysis. X-Ray Determination of Alloys Equilibrium Diagrams, A. F. Westgren. Am. Inst. Min. and Met. Engrs.—Inst. Metals Division—Trans., for mtgs. Sept. 22–26, 1930, and Feb. 16–19, 1931, pp. 13–38, 19 figs. Equilibrium diagrams of many alloys have not yet been accurately determined; most investigators apply thermal analysis and metal microscopy in their research; data obtained by those studying same system independently are often divergent; X-ray crystallography offers more accurate methods; cameras; preparation of samples; indentification of alloy phases; homogeneity ranges in equilibrium diagrams; intermetallic compounds and solid solutions; structure analogies. Bibliography.

ALUMINUM

Protective Coatings. Surface Treatment of Aluminium and Its Alloys. Chem. Age, vol. 25, nos. 627 and 631, July 4, 1931 (supp.) 1–2, and Aug. 1 (supp.) pp. 7–8. July 4: Survey of modern practice based on information supplied by British Aluminum Co., of London, dealing with principles of surface treatment for various purposes; protection against chemical, physical, and mechanical action; electric insulation; metallic contact; heat absorption. Aug. 1: Processes in which chemicals are used for production of protective films.

AMMONIA COMPRESSORS

High-Pressure. Hoechstdruckkompressoren fuer die Ammoniak-Synthese (Super-Pressure Compressors for Ammonia Manufacture), Schneider. Brennstoff-Chemie. vol. 12, no. 14, July 15, 1931, pp. 273–276, 6 figs. Examples of piston compressors installed in gas-pumping stations for long-distance gas supply of Thyssen Gas and Water Works; coke-gas compressors, with two-stage compression, having hourly output of 8000 cu. m. coke-oven gas; Demag super-pressure compressors, installed in nitrogen plant of Ruhr Chemie A.G., have hourly output of 6000 cu. m. of mixed gas; change in atmospheric pressure from 10 to 900 atmos. is effected in four stages.

AUTOMOBILE ENGINES

Cooling. Leistungssteigerung der Kuehlanlagen mit Pumpenumlauf bei Kraftwagen (Improving Performance of Cooling System With Pump Circulation in Motor Vehicles), W. Riede. V.D.I. Zeit., vol. 75, no. 29, July 18, 1931, pp. 929–933, 8 figs. Possibilities of increasing efficiencies of cooling system; power requirements and output of different types of fans; resistance of different types of radiators to airflow; performance of centrifugal pump depending on temperature of water; efficiencies of different types of cooling systems at different water temperatures; results of road tests.

Valves. Ingenious Rotary Valve Engine. Motor (Lond.), vol. 60, no. 1547, Aug. 18, 1931, p. 91, 2 figs. Features of Baer valve as fitted to six-cylinder engine; ports through which gases pass to and from cylinders run diametrically across valve driven at only one quarter crankshaft speed.

AUTOMOBILES

Bodies—Manufacture. The Manufacture of Pressed-Steel Automobile Bodies and Components. Engineering, vol. 132, no. 3423, Aug. 21, 1931, pp. 239–241, 6 figs. Methods employed at works of Pressed Steel Co. of Great Britain; most important tools in shop are two Keller die-sinking machines, operated by means of keyboard; shop has capacity of 20,000 pressing operations per hour, and is served by two 20-ton and two 10-ton overhead cranes.

Springs and Suspension. Lancia Spring Said to Eliminate Shimmy and Wobble, P. Balma. Automotive Industries, vol. 65, no. 7, Aug. 15, 1931, pp. 232–233 and 236, 1 fig. Advantages of Lancia design, with particular regard to low unsprung weight obtained by use of coil springs; independent springing with stiff frame and axle result in important improvements in riding qualities.

Streamline. Streamlining Applied to Automobiles, O. K. Marti. Soc. Automotive Engrs.—Jl., vol 29, no. 2, Aug. 1931, pp. 126–128 and 163, 7 figs. Results of wind-tunnel tests of streamlined automobile models show reduction by almost one-half in wind resistance at speeds of 40 and 50 m.p.h., as compared with conventional American sedan model; theoretical analysis of horsepower required to maintain given car speed.

AUTOGIROS

Principles. The Autogiro, D. J. de la Cierva. Aeroplane, vol. 41, no. 8, Aug. 19, 1931, pp. 462 and 463. General principles and performance characteristics; advantages of rotor arrangement over conventional airplane design.

AUTOMOTIVE FUELS

Detonation. Time Lag in Detonation Determinations, N. Mac Coull. Soc. Automotive Engrs.—Jl., vol. 29, no. 2, Aug. 1931, pp. 139–140, 2 figs. Investigation of phenomena met in matching one fuel against another directly with double-float carburetor; knock sometimes either disappears or increases in intensity when change from one fuel to other is made.

B

BEARINGS

Anti-Friction—Lubrication. Lubrication of Ball and Roller Bearings, H. E. Brunner. Machy. (N.Y.), vol. 38, no. 1, Sept. 1931, pp. 30–32, 1 fig. Results of extensive tests conducted by S K F Industries, Inc., to determine proper lubrications and methods of application according to operating conditions.

BELT DRIVE

Friction in. Elastizitaet und Reibung beim Riementrieb (Elasticity and Friction in Belt Driving, G. Duffing. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no 3, Mar. 1931, pp. 99–104, 8 figs. Behavior of perpendicular belt at rest and under load; results of tests; behavior of belt at no load; new friction formula developed in which constants are so determined that it can be used for series of tests with different pulley diameters and speeds.

BELTS AND BELTING

Leather. Rules to Observe in Selecting Good Leather Belting, E. Perry. Indus. Transmission and Conveying, vol. 39, no. 1, July 1931, pp. 9–10 and 19–20, 1 fig. Practical discussion of specifications for leather belting selection; stretch test; pulley-cover stock; pulley diameter and speed; endless belts; requisites of slack belts.

BOILER FEEDWATER

Treatment. The Colloidal Conditioning of Boiler Feed Water, J. McNaught. Eng. and Boiler House Rev., vol. 45, no. 2, Aug. 1931, pp. 80–82, 3 figs. Underlying principles of boiler-feedwater treatment; ill effects summarized under three headings of scale, corrosion, and embrittlement; advantages of colloidal conditioning over other treatments for priming prevention. Before Liverpool Eng. Soc.

BOILERS

Corrosion. Chemical Embrittlement of Boilers, W. W. Robinson, Jr. Petroleum World (Los Angeles), vol. 28, no. 2, Feb. 1931, pp. 63–67, 89 and 90–92, 11 figs. Causes of destructive caustic action; types of cracks; character of embrittlement cracks; effect of sulphate content.

Design. Entwurf und Aufbau von Hockleistungskesseln (High-Capacity Boilers), R. Boese and F. Beuthner. Waerme, vol. 54, no. 31, Aug., 1931, pp. 581–587, 14 figs. Rules for layout and design of high-duty boilers, and their application to different elements (furnace, boiler, superheater, economizer, and air preheater).

The Single-Pass Boiler and Its Economic Field, O. deLorenzi. Power Plant Eng., vol. 35, no. 15, Aug. 15, 1931, pp. 837–839, 2 figs. New straight-tube single boiler with no economizer, air heater or induced-draft fan fills need for high efficiency and high availability; sectional views and operating advantages.

Furnaces—Design. The Assessment of Boiler-Furnace Dimensions, C. E. H. Verity. Power Engr., vol. 26, no. 305, Aug. 1931, pp. 287–290, 9 figs. Outline of logical basis for comparing water-wall and grate areas in different furnace designs; types of water-wall construction; grate-area calculations

Furnaces, Water-Cooled. Water-Cooled Furnace Bottoms, O. deLorenzi. Combustion, vol. 3, no. 2, Aug. 1931, pp. 16–19, 5 figs. Design of furnace bottoms has been of primary importance in development of pulverized-fuel firing; development and review of several patents which have marked its various stages, beginning with invention and practical application of water-cooled bottom or so-called bottom screen; patent, applied for in 1920 laid groundwork for all later progress in pulverized fuel firing, and, as embodied in more recent patent in conjunction with side-wall cooling, is basic feature of modern pulverized-coal fired furnaces.

Natural-Gas. Natural Gas as Fuel in Power Plants, E. A. Bending. Combustion, vol. 3, no. 1, July 1931, pp. 21–31, 10 figs. Data and information dealing with constituents and analyses of natural gas; curves illustrating natural-gas boiler firing; features of various types of burners; gas measurements; fuel selection; chart showing evaporative costs for coal, oil, and gas.

Plates—Alloy Steel. Warmfeste und korrosionsbestaendige Staehle fuer den Dampfkesselbau (Heat and Corrosion-Resisting Steels for Boiler Construction), H. Jungbluth and H. Mueller. Zeit. des Bayerischen Revisions-Vereins, vol. 35, no. 12, 13, and 14, June 30, 1931, pp. 140–143, July 15, pp. 155–158, and July 31, pp. 173–175, 16 figs. Methods of testing and results obtained; authors have found molybdenum and certain chromium-molybdenum steels greatly superior to other steels; results of tests carried out on steels made by F. Krupp Corp.

Plates—Cracking. Accelerated Cracking of Mild Steel (Boiler Plate) Under Repeated Bending, W. Rosenhain and A. J. Murphy. Iron and Steel Inst.—Advance Paper, no. 16, May 1931, 19 pp., 24 figs. partly on supp. plates. Bars of boiler-plate steel and of cold-rolled mild steel were subjected to repeated bending in alternate directions while in contact with various media; practical significance of results is discussed, together with proposals for further investigation.

Boiler Failures and Their Causes. Engineering, vol. 132, no. 3423, Aug. 21, 1931, pp. 241–243, 2 figs. Reports dealing with causes and prevention of boiler failures presented before German Association of Boiler Owners at Dresden.

Ueber die Ursache von Dampfkesselschaeden (Causes of Boiler Failures), O. Bauer. Waerme, vol. 54, no. 30, July 25, 1931 pp. 567–574, 20 figs. Causes of failure are due to properties of materials, influence of treatment on properties of material, and design and operation of plant; examples of faulty welding work; welding of cracks is usually of no value and dangerous, as repair does not eliminate cause of damage.

Pulverized-Coal. Slag-Tap Furnace at Valmont. Elec. West, vol. 67, no. 3, Sept. 1, 1931, pp. 112–114, 3 figs. Public Service Co., of Colorado Station of 45,000-kw. peak capacity; new boiler is Babcock & Wilcox cross-drum water-tube boiler with vertical forged-steel sectional headers; total heating surface is 21,398 sq. ft. with slag screen having additional 1050 sq. ft.; maximum steam working pressure in boiler drum is 425 lb. per sq. in.

Water Tube. Ein Neuartiger Teilkammerkessel (New Type of Sectional Boilers), K. G. Voswinckel. Waerme, vol. 54, no. 32, Aug. 8, 1931, pp. 603–604, 3 figs. Straight-tube boiler is characterized by undisturbed heat expansion, water circulation along definite path, any desired arrangement of ascending and downcoming pipe cross-section, free ash disposal of back drafts, and very simple construction.

Wood-Waste. Furnaces for Waste Fuels, O. deLorenzi. South. Power Jl., vol. 49, no. 7, July 1931, pp. 40–44, 8 figs. Many waste products of industrial processes now used as fuel due to development of combustion methods and furnace design; twofold purpose achieved thereby: waste products are destroyed and valuable fuel obtained; key to satisfaction lies in furnace design.

BRASS

High-Strength—Failure of. Note on the Failure of a High-Strength Brass, J. E. Newson and A. Wragg. Inst. Metals—Advance Paper, no. 578, for mtg. Sept. 14–15, 1931, 9 pp., 10 figs. partly on supp plate. Experiments to indicate source and cause of isolated cases of failure observed in bars of high-strength brass; reeling process for straightening, after extrusion, in case of brass with high yield point, is responsible for residual stresses of such order, that failure due to internal cracking may result during storage, or subsequent machining; suitable low-temperature annealing treatment effectively removes all possibility of residual stress cracking.

Pressure-Service. Bronze Pressure Castings, J. E. Crown. Metal Industry (N. Y.), vol. 29, no. 8, Aug. 1931, pp. 335–337, 3 figs. Manufacturer of bronze castings for pressure service demands high-grade product; factors listed of most importance are: selection of alloys, design of pattern, allowance for machine finish, method of molding, character of cores, and types of heads and gates. Before Am. Foundrymen's Assn.

BRONZE CASTINGS

Permanent Molds. Bronze Castings Now Made in Permanent Molds, H. Marius. Iron Age, vol. 128, no. 12, Sept. 17, 1931, pp. 756–758, 2 figs. In space 30 by 100 ft. and with total working force of six unskilled mechanics, Lenoir Car Works, sets up, pours, and shakes out 130 to 150 molds with total weight of over 20,000 lb., in 8-hr. shift; pouring temperatures, melting conditions, gating risers, wall thickness of molds, clamping molds and type of iron in molds. Before Am. Foundrymen's Assn.

C

CALCULATING MACHINES

Gears of. Getriebe der Multipliziermaschinen

(Gears of Multiplying Machines), W. Lind. V.D.I. Zeit., vol. 75, no. 31, Aug. 1, 1931, pp. 985–990, 29 figs. Operating principles of simple multiplication machine; classification and action of principal parts; relation between multiplying and dividing; comparison of design practice of representative makes.

CARBON DIOXIDE

Solid—Manufacture of. The Manufacture of Solid Carbon Dioxide, C. L. Jones. Ice and Refrig., vol. 81, no. 3, Sept. 1931, pp. 177–180, 7 figs. Features of new plant erected by Dry Ice Corp. of America at Peoria, Ill.; raw material drawn from gases produced as by-product of solvent manufacture; development of market for product; preparation and shipping of finished cubes.

CASE-HARDENING

Carburizing. A New Method of Case-Hardening in an Electric Furnace. Mar. Engr. and Motorship Bldr., vol. 54, no. 648, Sept. 1931, p. 351, 1 fig. Equipment introduced into England by Wild-Barfield Electric Furnaces, Ltd.; description of process, with costs of operation.

The Role of Energizers in Carburizing Compounds, G. M. Enos. Am. Soc. Steel Treating—Preprint, no. 36, for mtg. Sept. 21–25, 1931, 23 pp., 6 figs. Effects of various materials as energizers in carburization and mechanism of carburization with reference to carbon transfer from compound to steel; experimental work on various phases of carburization are still in progress, hence definite conclusion may be premature.

Recent Research. Die Einsatzhaertung (Case Hardening), H. Mueiler. Archiv fuer das Eisenhuettenwesen, vol. 5, no. 1, July 1931, pp. 57–62, 20 figs. on supp. plate. Compilation of more recent research results; normal and abnormal steel: gaseous and liquid cementation agents (carbon, nitrogen) in pure and mixed form; heat treatment.

CAST IRON

Alloy. Characteristics of Alloyed Cast Iron, F. W. Shipley. Am. Soc. Steel Treating—Preprint, no. 25, for mtg. Sept. 21–25, 1931, 20 pp., 23 figs. Increased quality which is reflected through higher valve-seat hardness and improved microstructure can be obtained by additions of nickel and chromium to automotive-type cylinder iron; effect of prolonged heating on three representative plain irons as well as on three nickel-chromium-alloyed irons of same base composition is also shown and again marked difference is revealed in favor of alloyed irons; method of producing chilled roller wheels by additions of chromium instead of special cupola charges is given.

Fatigue. Steady Torsion Combined With Alternating Bending, J. B. Kommers. Engineering, vol. 132, no. 3424, Aug. 28, 1931, p. 249, 1 fig. With reference to paper by F. Bacon, before South Wales Institute of Engineers, writer points out that Gerber's parabola does not fit experimental results for cast iron; he has found that B. P. Haigh's equation for representing results of fatigue tests applies very well for those fatigue results on cast iron in which mean stress is positive; criterion is developed for combined torsion and bending; method employed follows that used by Bacon.

CHAIN DRIVE

Roller—Lubrication of. Lubrication and Maintenance of Roller-Chain Drives, W. A. Warrick. Power, vol. 74, no. 7, Aug. 18, 1931, pp. 235–238, 4 figs. Suggestions for installation, care, and lubrication of roller-chain drives, that, if applied, will insure high-grade service and long life of chains and sprockets as well as low operating costs.

CHROMIUM-MOLYBDENUM STEEL

Welding. Einfluss der Gasschmelzschweissung auf die Biegungsschwingungsfestigkeit von Chrome-Molybdaen-Stahlrohren (Effect of Oxy-acetylene Welding on Torsional Vibration Strength of Chromium Molybdenum Steel Tubing), H. Beissner. V.D.I. Zeit., vol. 75, no. 30, July 25, 1931, pp. 954–956, 8 figs. Effect of molybdenum on properties of materials with particular regard to welding characteristics of chromium molybdenum steel tubing; testing methods and equipment for determining torsional vibration strength of chromium-molybdenum steel tubing before and after welding; practical suggestions regarding choice of welding rod, and wall thickness.

CHROMIUM-NICKEL IRON

Constitutional Diagram. Further Studies on Chromium-Nickel-Iron and Related Alloys, V. N. Krivobok, E. L. Beardman, H. J. Hand, T. O. A. Holm, A. Reggiori, and R. S. Rose. Am. Soc. Steel Treating—Preprint, no. 33, for mtg. Sept. 21–25, 1931, 40 pp., 27 figs. Theoretical considerations concerning chromium-nickel-iron-carbon constitutional diagram, with factors influencing existence of metastable phases, and, in consequence of latter, with so-called "decomposition" or "disintegration" of these alloys.

CHROMIUM PLATING

Hardness of. Hardness of Chromium as Determined by the Vickers-Brinell, Bierbaum, and Mohs Methods, R. Schneidewind. Am. Soc. Steel Treating—Preprint, no. 2, for mtg. Sept. 21–25, 1931; 18 pp., 9 figs. Hardness of electrodeposited chromium was found to be 625 Brinell, 8 on Mohs scale, and gave scratch width of 2 microns with Bierbaum microcharacter; heating at 290 deg. cent. caused sudden drop in hardness due probably to volatilization of hydrogen; no exact relationships could be found between hardness of metals as measured by three methods mentioned, although logarithms of Brinell and Mohs hardnesses for pure annealed metals seem to be related fairly well.

COMBUSTION

Bituminous Coal. Verbrennungsverlauf bei Steinkohlen mittlerer Korngroessen (Combustion of Bituminous Coals of Medium Grain Size), H. Werkmeister. Archiv fuer Waermewirtschaft, vol. 12, no. 8, Aug. 1931, pp. 225–232, 17 figs. Results of extensive series of tests; investigation by special method of combustion of Ruhr nut coals with different gas content; results are shown in form of characteristic combustion curves in relation to combustion time; approximate formulas for calculation of technical combustion process.

Theory. Das It-Diagram der unvollstaendigen Verbrennung (Heat Content-Temperature Diagram for Incomplete Combustion), P. Rosin and R. Fehling. V.D.I. Zeit., vol. 75, no. 30, July 25, 1931, pp. 959–963, 16 figs. Relations between air requirements, combustion gas volumes, heat content and heating value for incomplete combustion; effect of water-gas equilibrium on ratio of free to latent heat; heat-content diagram and thermal efficiency.

CONVEYORS

Screw. Screw Conveyors. Mech. World, vol. 90, no. 2331, Sept. 4, 1931, pp. 228–230, 6 figs. Application; materials used in construction; sizes; speeds; feed; discharge; construction; drive; erection; formulas used in design.

COPPER

Properties. The Work-Hardening Capacity and Elongation Properties of Copper, H. O'Neill and J. W. Cuthberton. Inst. Metals—Advance Paper, no. 580, for mtg. Sept. 14–15, 1931, 17 pp., 3 figs. Various methods of obtaining elongation values of tensile test pieces have been applied to specimens of copper in annealed and increasingly cold-rolled condition; indentation tests which may be considered to estimate work-hardening capacity have also been applied to same specimens for purposes of comparison.

COPPER-NICKEL ALLOYS

High Elastic Limit. Nickel—Copper Alloys of High Elastic Limit, D. G. Jones, L. B. Pfeil and W. T. Griffiths. Inst. Metals—Advance Paper, no. 573, for mtg. Sept. 14–15, 1931, 18 pp., 7 figs. partly on supp. plates. Investigation was undertaken primarily in order to obtain reliable values for elastic limit of nickel-copper alloys containing up to 50 per cent of nickel, but determinations were also made of maximum stress, elongation, and reduction in area.

CRANES

Types. Enquete sur l'état actuel de la technique des appareils de Levage et de Manutention Mécanique (Enquiry on the Actual Situation of the Technique of Lifting Apparatus and Mechanical Handling Gear), M. Pelou. Science et Industrie, vol. 15, nos. 210 and 211, July and Aug., 1931, pp. 335–347, 27 figs., and 383–395, 25 figs. July: Gantry cranes and semi-gantry cranes constituting one of most important categories, traveling cranes, and pillar cranes. Aug.: Several examples of hammer-head cranes; derrick cranes and floating cranes; field of application of different types of cranes.

CUPOLA PRACTICE

Waste-Heat Utilization. Utilize Waste Heat in Hot Blast Cupola. Foundry, vol. 59, no. 17, Sept. 1, 1931, pp. 71–72, 1 fig. Chemical reactions in cupola; methods of Griffin Wheel Co., permitting substantial fuel savings and more uniform control; graphs illustrate typical arrangement for waste-heat recovery and utilization in preheating cupola blast.

CUTTING TOOLS

High-Speed. Super High-Speed Steel, J. M. Highducheck. Am. Mach., vol. 75, no. 12, Sept. 17, 1931, pp. 450–454, 5 figs. Materials, heat treatments, and rake angles designed to meet demand for more chips per minute; chart shows complete list of forged tool shapes that are considered standard for everyday production.

[See also TANTALUM CARBIDE; TUNGSTEN.]

D

DIESEL ENGINES

Compression. Vorgaenge beim Verdichtungshub von Vorkammer-Diesel-maschinen (Phonomena During Compression Stroke of Ante-Chamber Diesel Engines), K. Schlaefke. V.D.I. Zeit., vol. 75, no. 33, Aug. 15, 1931, pp. 1043–1046, 12 figs. Mathematical investigation of thermodynamic phenomena during compression stroke; graphs illustrate relation between operating temperature, turbulence, compression ratio, etc.

Cylinders. Diesel Engine Cylinder Lubrication, A. M. Tode. Power Plant Eng., vol. 35 no. 15, Aug. 1, 1931, pp. 792–795, 6 figs. Two-cycle and four-cycle engine; effects of temperature and pressure; proper methods of supplying oil; quantity of cylinder oil feed; over-lubrication.

Fuel Injection. The Effect of Injection-Valve Opening Pressure on Spray-Tip Penetration, A. M. Rothrock and E. T. Marsh. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 384, July 1931, 4 pp., 3 figs. on supp. plates. For given injection pressure, using injection-valve opening, pressure of same value as injection pressure resulted in maximum rate of penetration as excess of injection pressure over injection-valve opening pressure was increased for given injection pressure, effect of injection-valve opening pressure on spray-tip penetration was increased.

The N.A.C.A. Apparatus for Studying the Formation and Combustion of Fuel Sprays and the Results From Preliminary Tests, A. M. Rothrock. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 389, Sept. 1931, 22 pp., 16 figs. on supp. plates. Formation and combustion of fuel sprays in high-speed compression-ignition engine; cylinder head of engine has vertical disk form of combustion chamber whose sides are glass windows; motion pictures at rate of 2000 per sec. are taken of spray formation by means of spark discharges.

Fuels for. Fuels for Automotive Diesels, W. H. Butler. Diesel Power, vol. 9, no. 9, Sept. 1931, pp. 456–459, 4 figs. Two possible methods of obtaining satisfactory performance of high-speed Diesel-engine fuels; list of major problems of developing high-speed Diesel fuels; possibility of catalyst of ignition oils; distillation curve of oil for high-speed Diesel engine; distillation curves for three representative oils. Before Soc. Automotive Engrs.

High-Speed. Can the High-Speed Diesel Engine Compete With the Gasoline Engine, H. D. Hill. Diesel Power, vol. 2, no. 8, Aug. 1931, pp. 403–406 and (discussion), 406–409, 13 figs. Design problems of solid-injection fuel systems of small, high-speed engines; construction and operating details; application of Hill Diesel engine to 3-ton truck. Before Soc. Automotive Engrs.

The Blackstone High-Speed Oil Engine. Motive Power, vol. 2, no. 8, Aug. 1931, pp. 24–25, 3 figs. New "spring injection" system employed on line of oil engines produced by British firm; new line of high-speed crude-oil engines manufactured in 2-, 4-, and 6-cylinder sizes; engines offer range in power from 18 to 20 hp. in smallest engine and 36 to 40 hp. in 4-cylinder engine to 55 to 60 hp. in large 6-cylinder unit; normal operating speed 1000 r.p.m.; illustrated description of design and constructional features.

Marine (Sulzer). 7600-B.H.P. Double-Acting Two-Cycle Marine Diesel Engine. Engineering, vol. 132, no. 3420, July 31, 1931, pp. 147–149, 6 figs. Sulzer Bros. have introduced engine which incorporates results of extensive tests, spread over several years, on double-acting types, of medium and large cylinder output; engine described has normal service rating of 7600 b.hp., is of 8-cylinder type and runs at 106 r.p.m.; it will be installed in single-screw motorship "Tanjandoen."

Scavenging. Untersuchungen an der Dieselmaschine (Studies of Diesel Engines), K. Neumann. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 8, Aug. 1931, pp. 273–286, 14 figs. Thermodynamic principles of scavenging and charging process of 2-stroke-cycle engines.

E

ELECTRIC FURNACES

Heat-Treating. Anneals High-Speed Steel in Pit-Type Furnace, W. S. Scott. Steel, vol 89, no. 12, Sept 17, 1931, pp. 35–36 2 figs. Design and operation of pit-type electric furnace having vertical crucible made of cast nickel-chromium alloy $17^1/_4$ in. diam. and $35^1/_2$ in. deep, and sand-sealed door; equipped with two thermo-couples and 2-point recording and controlling pyrometer.

ELECTRIC WELDING

Arc—Types of. Gleichstrom-, Einphasenstrom- oder Drehstrom-Lichtgenschweissung (Direct-Current, Single-Phase or Three-Phase Arc Welding), J. C. Fritz. Elektrotechnische Zeit., vol. 52, no. 29, July 16, 1931, pp. 932–934. Advantages and disadvantages compared, it is shown that recently in Germany more and more single-phase arc comes to fore in use of shielded quality electrodes; principles of recent special arc-welding equipment.

ENGINEERING EDUCATION

Research in. The Function of Research in Engineering Education, D. C. Jackson. Science, vol. 74, no. 1912, Aug. 21, 1931, pp. 183–187. Research not only has function in engineering education but is integral part of properly conceived engineering education; investigatory spirit and achievement are more important attributes for engineering teacher than higher degrees; spirit for establishing research laboratories and foundations in engineering schools is presage of good educational spirit in schools. Before Soc. Promotion Eng. Education.

ENGINEERS

Registration. Important Changes Proposed in Uniform Registration Law, T. K. Legare. Eng. News-Rec., vol. 107, no. 7, Aug. 13 1931, pp. 266–267. President, National Council of State Boards of Engineering Examiners, recommends definite educational qualifications for professional engineers and land surveyors; satisfactory definition of engineering sought.

Russia. American Engineers in Russia. J. M. Carmody. Eng. News-Rec., vol 107, no. 7, Aug. 13, 1931, pp. 262–264. Comments upon engineering status, living conditions, technical problems and future prospects; employment contracts; engineers must be teachers.

F

FANS

Centrifugal. Application of Centrifugal Fans C. A. Carpenter. Heat. and Vent., vol. 27, no. 8, Aug. 1931, pp. 45–50, 4 figs. Method of selecting proper fan for given application by use of new characteristic curves and diagrams which can be developed mathematically.

FLUIDS

Temperature Difference. A Nomogram for Logarithmic Mean Temperature Difference, B. M. Thornton. Engineering, vol. 132, no. 3422, Aug. 14, 1931, p. 194, 1 fig. Nomogram shown solves much-used formula for logarithmic mean temperature difference between two fluids.

FURNACES, INDUSTRIAL

Heat Losses in. Die Berechnung der Wandverluste industrieller Oefen (Calculation of Wall Losses in Industrial Losses), E. Maase. Feuerfest, vol 7, no. 7, July 1931, pp. 97–102, 8 figs. Significance and cause of heat losses in furnace walls; losses due to piping; numerical and graphic calculation of losses; relation between heat-conductivity coefficient and physical properties; losses due to gas permeability.

G

GAGES

Contour-Recording. Recording Contour Gage, E. C. Erickson. Am. Mach., vol. 75, no. 4, July 23, 1931, pp. 167–169, 5 figs. Visual recording method of measuring variation in plane surface, either of itself alone or in its relation to adjacent planes; developed at Bell Telephone Laboratory for telephone diaphragms; diagrammatic sketch showing essential elements and light paths.

GEARS

Friction. Variable Speed Friction Gear. Engineer, vol. 152, no. 3947, Sept. 4, 1931, pp. 250–251, 5 figs. New type constructed under patents of Hele-Shaw and T. E. Beacham.

Heat Treatment. Heat Treatment Assures Dependable Gears. Iron Age, vol. 128, no 11, Sept. 10, 1931, pp. 684–687 and 721, 3 figs. Methods and equipment at plant of Meisel Press Mfg Co., Boston, Mass., manufacturer of large printing presses, producing gears on large scale for own use, as well as for makers of airplane engines and heavy machinery.

Involute. Meeting Modern Conditions in New Gearing Formulas, G. H. Middleton. Machine Design, vol. 3, no. 8, Aug. 1931, pp. 41–44, 3 figs. Investigation of contact of involute gear teeth.

Worm. A Worm Hob Design, N. Trbojevich. Am. Mach., vol. 75, no. 9, Aug. 27, 1931, pp. 348–350, 7 figs. Change in flute angles gives free cutting, uniform sizing, and burnished finish; flutes are formed from two dissimilar helices causing them to become narrower at large end of hob developed by Timken Detroit Axle Co.

GRINDING MACHINES

Grinding From Drawing. Grinding Direct From the Drawing, O. P. Van Steewen. Am. Mach., vol. 75, no. 10, Sept. 3, 1931, pp. 367–371, 14 figs. Grinding tool or templet direct from drawing achieved simply in machine designed by Seidel & Naumann, Dresden; three principal parts: work slide, grinding-wheel head, and pantograph with microscope and drawing board are illustrated by sketches.

H

HARDNESS TESTING

Brinell. Note on the Diameter Measurement of Certain Brinell Indentations in Cold-rolled Metal, H. O'Neill Inst. Metals—Advance Paper, no. 579, for mtg Sept. 14–15, 1931, 4 pp., 3 figs. on supp plate. Owing to shape of lip of indentations made by Brinell test in certain cold worked metals, diameter measurements of indent may differ by 3 to 4 per cent according to whether vertical or oblique illumination is used with measuring microscope.

HIGH-SPEED STEEL

Aging. Aging in Low-Carbon Steels, A. A. Bates. Am. Soc. Steel Treating—Preprint, no. 13, for mtg. Sept. 21–25, 1931, 24 pp., 27 figs. Relationships between quenching temperature and aging ability of extra soft steels; degree of age-hardening of which low carbon steel is capable may be compared favorably with that of duraluminin and other aluminum alloys.

Testing. Some Physical Properties of High-Speed Steel, J. V. Emmons. Am. Soc. Steel Treating—Preprint, no. 22, for mtg. Sept. 21–25, 1931 31 pp., 48 figs. Study of high-speed steel of familiar 18–4–1 type; hardening and drawing temperatures are varied through wide ranges and effect of variations on some of physical properties of steel is examined; mechanical properties of strength and plasticity are measured by torsion method; numerical value for toughness is calculated; Rockwell hardness is determined and study is made of microstructure at high magnification.

HOOKS

Stresses in. Versuche ueber die Spannungsverteilung im Zughaken (Stress Distribution in a Drawbar Hook), K. Boettcher Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 337, 1931, 20 pp., 24 figs. Investigation proves that tangential stresses normally to plane of section, and particularly highest stresses at interior edge, are calculated with sufficient accuracy by Grashof formula, most elementary and oldest of solutions; statement is conditional, however, upon supposition that curvature is nearly uniform; tests show influence of change of curvature.

HYDRAULIC TURBINES

Propeller-Type. Propeller Type Water-Turbines, C. S. T. Paul. Instn. Mech. Engrs.—Proc., vol. 2, pp. 1409–1421, 7 figs. Features of Gill Lawaczeck, Kaplan, Bell, and Moody turbines.

HYDROELECTRIC POWER PLANTS

Austria. Das Stubachwerk I. (Stubach Plant), A. Hruschka. Elektrotechnik und Maschinenbau, vol. 49, nos. 22, 23, and 24, May 31, 1931, pp. 417–427, June 7, pp. 437–446, June 14, pp. 460–471, 42 figs. Description of Austrian hydroelectric development involving construction of several dams up to 25 m. in height, tunnels 6.4 km. long, also 6 km. of steel pipe in tunnel section; installed are present 4 main Pelton wheels of J. M. Voith for 8000 hp. 472 m. head and 500 r.p.m. and 2 auxiliary units direct coupled to single-phase a.c. generators of 4000 kva. 680 volt at $16^2/_3$ cycles, detailed data on station and equipment of plant for supply to Austrian Federal Railroads.

Intakes. Recent Applications of Draft Distributors to Power Plant Intakes, H. G. Acres. Eng. News-Rec., vol. 107, no. 11, Sept. 10, 1931, pp. 403–410, 13 figs. Rational design of intakes long neglected; studies made for Queenston-Chippawa plant in Canada led to development of Johnson-Wahlman draft distributor; four intakes designed to meet diverse conditions; elements of ideal intake design; intake of Chelan development of Washington Water Power Co. of Spokane; 14 ft. and 17 ft. in diam.; intake for St. John River Power Co. at Grand Falls, New Brunswick; delivers 7500 sec. ft.; design of intake for projected development of 10,000 to 12,000 sec. ft. capacity.

Manitoba. Seven Sisters Hydro-Electric Development, F. H. Martin. Eng. Jl., vol. 14, no. 7, July 1931, pp. 379–392 and (discussion) 392–393, 12 figs. This is third hydroelectric development undertaken by Winnipeg Electric Co. and is situated on Winnipeg River, 63 mi. from Winnipeg; initial development will produce 60,000 s.hp. and final installation will have total capacity of 225,000 hp under 66-ft. head; dikes extend up river from dam for several miles on both sides of river; power house is of solid gravity spillway type; three high-specific-speed propeller turbine units of different manufacture are being installed, each of 37,500 hp. rated capacity.

Ontario. The Upper Notch Automatic Hydro-Electric Power Plant, R. F. Legget, P. J. Croft and J. R. Desloover. Eng. Jl., vol. 14, no. 8, Aug 1931, pp. 437–444, 12 figs. Upper Notch plant located on Montreal river, 15 miles southeast of Cobalt, northern Ontario, consists of two 48-ft. head 6500 hp., 125 r.p.m. turbines; and two 6500-kva., 11,000-volt, 25-cycle generators; switchgear and control equipment are fully automatic and are designed for possible remote control from distant supervisory point; switchgear is of metal-clad type station output is transformed to 110,000 volts by three 4500-kva. transformers and it is fed into extensive transmission network by means of line 32.7 mi. long.

United States. The White Rapids Automatic Station of the Northern Electric Company, H. W. Gochnauer. Gen. Elec. Rev., vol 34, no. 9, Sept. 1931, pp. 507–511, 4 figs. Northern Paper Mills of Green Bay (Wis.) developed White Rapids on Menominee River; power units consist of 3 S. Morgan Smith vertical turbines connected to 2300-volt General Electric alternators, two of which are rated 3750 kva. and one 2500 kva.; two sizes of generators were installed to provide for various quantities of water; water wheels are of Francis type of two sizes to operate under head of 29 ft. at 100 and 120 r.p.m.; station is completely automatic except that starting and stopping indications are given by operator.

I

IMPACT TESTING

Notched-Bar. Der Stand Der Kerbschlagproben Frage in Deutschland (The Notched Bar Impact Test Problem in Germany), M. Moser. Int. Congress for Testing Matls.—Advance Paper, 1931, 14 pp., 10 figs. Final elucidation of practical value of test investigations tending toward adoption of smaller test piece that would lend itself to more general application then present standard test piece.

Meaning of the Notched-Bar Impact Test for Investigation and for Acceptance Test Purposes, R. H. Greaves. Int. Congress for Testing Matls. —Advance Paper, 1931, 7 pp., 5 figs. Features of test; fracture may occur by shear accompanied by considerable deformation or by three-dimensional tensile stress accompanied by little deformation; transition from one type to other may be brought about by relatively small changes in dimensions of test piece, of form of notch, or of speed or temperature of deformation.

INDUSTRIAL MANAGEMENT

Budget Control. Der industrielle Haushaltplan—ein Hilfsmittel der Wirtschaftsfuehrung (Industrial Household Plan—A Means of Economic Management), G. Wolff. V.D.I. Zeit., vol. 75, no. 31, Aug. 1, 1931, pp. 981–984, 6 figs. Budgetary control as applied to management and production planning in industrial plants.

The Need of Adjustable Budgets for Control of Business Operations, F. J. Heinritz. Nat. Assn. Cost Accountants—Bul., vol. 13, no. 1, Sec. II, Sept. 1, 1931, 63 pp. Need of making budget elastic or adjustable so that it can be adopted to meet changing conditions; budget system illustrated with specific example.

Cost Accounting. Distribution Cost Accounting. Nat. Assn. Cost Accountants—Bul., vol. 13, no. 1, sec. I, Sept. 1, 1931, 16 pp., 4 figs. Results of investigation to be applied in solution of selling and distribution costs; methods adopted have been used after examination into other possible statistical methods; salesmen's salary and expense; determination of amount of promotion and selling work; distribution of selling expense.

Modern Trends in Cost Accounting, A. W. Bass. Nat. Assn. Cost Accountants—Bul., vol. 12, no. 24. sec. I. Aug. 15, 1931, pp. 1897–1907. Control of equipment essential; budget development; standard costs; developing labor standards; material standards; control through standard costs. Bibliography.

Must Fixed Expenses Be Fixed? C. E. Knoeppel. Factory and Indus. Mgmt., vol. 82, no. 3, Sept. 1931, pp. 322–324, 7 figs. Basic cases of profit planning; practical application of laws to practical profit planning; curves of fixed cost and profit components of sales dollar.

Personnel Audit. How Armco Measures the Worth of Its Men. C. H. Murray. Iron Age, vol. 128, no. 10, Sept. 3, 1931, p. 611–613 and 630. American Rolling Mill Co. conducts annual "personnel audit" designed to point out relative abilities of its employees, from laborer to works manager, so that management has constantly available up-to-date inventory of personal characteristics.

Price Fixing. Scientific Pricing, L. S. Lyon. Taylor Soc.—Bul., vol. 16, no. 4, Aug. 1931, pp. 142–149. Preliminary considerations in making pricing a science; "price" making in communal or communistic society; pricing in field of railroads and public utilities; commodity exchanges; scientific pricing by manufacturer.

Production Control. Statistical Control, A. Hayes and R. F. Passano. Metal Progress, vol. 20, no. 3, Sept. 1931 pp. 94 98 and 101, 5 figs. How new science promotes uniformity of product by means of frequency curves; opportunities in statistical control.

The Gantt Chart in Russia, W. N. Polakov. Am. Mach., vol. 75, no. 7, Aug. 13, 1931, pp. 261–264, 2 figs. Experiences of author in Russia with Gantt chart for graphic control of production in plant employing over 5000 workers manufacturing precision machine tools, cutters, taps, and dies and full line of standard metal-cutting tools.

INDUSTRIAL TRUCKS

Electric. Material Handling Costs Cut by Electric Trucks, C. B. Crockett. Elec. World, vol. 97, no. 21, May 23, 1931, pp. 950–953, 10 figs. Economies of electric-truck operation in utility service; typical examples of convenience, economy, and safety; balance sheet proof of values.

INTERNAL-COMBUSTION ENGINES

Detonation. British Aero Laboratory Supplements Relation of Spark Plug Location Automotive Industries vol. 65, no. 9, Aug. 29, 1931, pp. 310–312, 6 figs. Effect of direction of flame movement on detonation; series of tests made with Ricardo engine having four spark plug positions and equipped with double-pole switch for quick changeover; effect of high inlet temperature.

Detonation. Spark Plug Position, and Engine Speed, R. O. King and H. Moss. Engineering, vol. 132, no. 3421, Aug. 7, 1931, pp. 177–180, 15 figs. Ricardo E. 35 variable-compression engine in Air Ministry Laboratory is of overhead-valve type, and has been used for experiments made to determine especially usable compression ratio, and corresponding power developed depending on whether spark-plug position causes flame movement to be toward exhaust valves or cooler inlet valves.

Vibrations. Théorie des oscillations de torsion des lignes d'arbres de moteurs à combustion interne (Theory of Torsional Vibrations of Internal-Combustion-Engine Shafting), J. Mancy. Bul. Technique du Bureau Veritas, vol. 13, no. 8, Aug. 1931, pp. 156–159. Oscillations of shaft subjected to external periodical forces; calculation of amplitude of oscillation; application of theory of oscillations.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES.]

IRON

Corrosion. Die Bedeutung der Wasserstoffaufnahme beim Loesungsvorgang des Eisens (Significance of Hydrogen Adsorption in Dissolution of Iron), E. Liebreich. Zeit. fuer Physikalische Chemie, vol. 155, no. 2, July 1931, pp. 123–142, 12 figs. Experimental checking of U. R. Evan's theory of corrosion of iron; corrosion of iron in hydrogen atmosphere; effect of corrosion products.

IRON AND STEEL

X-Ray Analysis. Fortschritt in der Roentgendurchstrahlung von Eisen (Progress in X-Ray Analysis of Iron), M. Widemann. Giesserei, vol. 18, no. 29, July 17, 1931, pp. 576–580, 4 figs. Factors governing progress in X-ray examination of metals, especially iron, of greater thickness; comparison of experimental results of Iron and Steel Institute of Berlin Institute of Technology, with other recent experimental results; conclusions.

IRON AND STEEL PLANTS

Great Britain. The Melting Shop of the Appleby Iron Company, Limited, A. Robinson. Iron and Steel Inst.—Advance Paper, no. 15, May 1931, 22 pp., 12 figs. partly on supp. plates. Works are situated at Scunthorpe, Lincolnshire, and owned by Frodingham Iron and Steel Co.; process is carried on in large tilting furnaces together with semi-active mixer; reasons for choice; layout of shop and equipment.

IRON-CARBON ALLOYS

Influence of Special Elements. Influence of Special Elements on the Carbon Content of the Iron-Carbon Eutectoid, E. L. Reed. Am. Soc. Steel Treating—Preprint, no. 32, for mtg. Sept. 21–25, 1931, 62 pp., 58 figs. Effect of nickel, manganese, chromium, tungsten, molybdenum, vanadium, silicon, copper, aluminum, cobalt titanium, and uranium on carbon content of iron-carbon eutectoid; segregation of carbon and special elements was made in some of alloy steels as cast: study of microstructure and hardness of special eutectoid steels was made after spheroidizing; effect of special elements on critical range. Bibliography.

Iron-Carbon Diagram. Some New Aspects of the Iron-Carbon Diagram, H. A. Schwartz. Am. Soc. Steel Treating—Preprint, no. 5, for mtg., Sept. 21–25, 1931, 27 pp., 8 figs. Purpose of paper is to awaken interest in viewpoint that equilibrium diagram is expression of definite energy relations and not merely plot of certain observed transformation points; conclusions are drawn as to metastability of free cementite at all temperatures above that at which work done in expansion restrains graphitizing reaction; graphitization is demonstrated in two unusually pure iron-carbon alloys.

L

LEAD ALLOYS

Hardness Testing. The Effects of Cold-Rolling and of Heat-Treatment on Some Lead Alloys. Inst. Metals—Advance Paper, no. 584, for mtg. Sept. 14–15, 1931, 23 pp., 28 figs. partly on supp. plate. Effects of cold rolling, heat-treatment, and storage on Brinell hardness of 14 lead alloys containing small additions of tin, cadmium, and antimony: hardness numbers of cast alloys ranged from 5 to 18 Brinell, cold rolling lying in all cases between 8 and 11 Brinell; self-annealing at atmospheric temperature further reduced hardness to about 7 Brinell.

LOCOMOTIVES

Design. Steam Locomotive Design: Data and Formulae, E. A. Phillipson. Locomotive, vol. 37, no. 468, Aug. 15, 1931, pp. 272–274. Advantages of feedwater heating, with especial reference to apparatus utilizing exhaust steam; quantity of exhaust steam necessary for feed heating; water economy due to use of feedwater heater.

Diesel-Electric. Diesel-Electric Locomotive for the Siamese State Railway. Engineering, vol. 132, no. 3422, Aug. 14, 1931, pp. 210–211, 2 figs. Locomotives made by Sulzer Bros. with output of 450 b.hp. are intended for operation on meter-gage railway, and have o.a. length of 44 ft. 6¾ in., with wheelbase of 9 ft. 10 in.; weight in service is 60 tons and adhesive weight 43 tons; engine has continuous output of 37.5 m.p.h.: it is of firm's standard heavy-oil locomotive type, and works on 4-stroke cycle; engine drives main and auxiliary generator.

Electric Storage-Battery. Die Akkumulator-Lokomotive als Kleinlokomotive fuer Unterwegsbahnhoefe (The Storage Battery Locomotive as Small Capacity Switching Locomotive), K. W. Landmann. Glasers Annalen, vol. 109, no. 4, Aug. 15, 1931, pp. 37–42, 4 figs. Small equipment by A.E.G. especially designed for shortening stopping time of freight trains at stations along road.

Frames—Failure. The Breakage of the Side Frames of Locomotives and of Bogie Trucks, J. D. Twinberrow. Engineering, vol. 132, no. 3424, Aug. 28, 1931, pp. 264–265, 5 figs. Detailed examination of number of broken frames led to conclusion that such fractures usually resulted from insufficient provision for safe transmission of horizontal forces which are developed by interaction of wheels and rails; influence of vertical load; horizontal loads.

Freight. Locomotive Designed for Service on the Canadian Prairies. Ry. Age, vol. 91, no. 5, Aug. 1, 1931, pp. 169–172, 3 figs. Canadian National sample 2–8–2 type makes good performance record in bad-water territory; satisfactory tests in fast-freight and in tonnage service; cylinders 24 by 30 in.; driving wheels 63 in.; boiler pressure 265 lb. per sq. in.; rated maximum tractive force 56,200 lb.; total engine weight in working order 337,200 lb.; total engine wheelbase 37 ft. 8 in.; design and constructional features.

2–10–4 Type Freight Locomotives for the Chesapeake and Ohio Railroad. Engineering, vol. 132, no. 3423, Aug. 21, 1931 pp. 226–228, 4 figs. New locomotives designed to haul, unassisted, coal trains of 11,000 short tons from Russell to Toledo, distance of 236 mi., over maximum grade of 0.7 per cent; these locomotives have more heating surface and larger grates than has ever before been used for non-articulated design.

Oil-Electric. Baldwin Builds Oil-Electric Locomotive. Ry. Elec. Engr., vol. 22, no. 8, Aug. 1931, pp. 205–207 and 221, 5 figs. Krupp Diesel engine developing 1000 hp. drives Westinghouse 500-volt d.c. generators; fuel cost per car mile indicates saving of 45 per cent over steam locomotive for similar service; list of principal dimensions, weights, and equipment; theoretical hauling capacity; tractive effort-speed curve.

Tank. An Interesting Locomotive Conversion. Ry. Gaz., vol. 55, no. 7, Aug. 14, 1931, pp. 212–213, 2 figs. Originally built with 4-4-4 wheel arrangement, tank engine changed over to 4-6-2 type with much increased adhesion weight; design and constructional features; leading dimensions of both types.

Testing. Test Locomotives of 4-8-2 and 2-6-6-2 Types on the B. & O. Ry. Age, vol. 91, no. 2, July 11, 1931, pp. 46–49 and 55, 7 figs. One of each type equipped with Emerson water-tube firebox; tests show economy in consumption of fuel and water; comparison table of existing Baltimore & Ohio locomotives with new 4-8-2 and 2-6-6-2 types built by Baldwin Locomotive works; average results of dynamometer road tests.

Tire Boring. Automatic Locomotive Tyre Boring at Swindon Works, G. W. R. Ry. Gaz., vol. 55, no. 4, July 24, 1931, pp. 111–113, 2 figs. Details of machine designed to permit rapid adjustment of tools to suit difficult tire sections; tool operations; repetition work.

LUBRICATING OIL

Evaluation. Die Berwertung der Schmiermittel fuer Waermekraftmaschinen (Evaluation of Lubricants for Heat Engines), E. W. Steinitz. Waerme, vol. 54, no. 35, Aug. 29 1931, pp. 645–650, 5 figs. It is claimed that lubricating capacity and lubricating value of lubricants is not yet measurable from practical standpoint; suggestions for indirect determination by analytical methods; relation of choice of lubricant and operating results is shown for reciprocating engines, Diesel engines and steam turbines.

Synthetic. The Field for Synthetic Lubricating Oils, F. W. Sullivan, Jr., V. Voorhees, P. T. Oak, and D. P. Barnard. Soc. Automotive Engrs.—Jl., vol. 29, no. 1, July 1931 pp. 40–44, 4 figs. Characteristics of two oils synthesized in commercial quantities; temperature-viscosity characteristics desirable for transmission and steering mechanisms and in hydraulic shock absorbers; less susceptible than usual oil to viscosity changes with temperature; comparative data on gear-shifting resistance, steering effort, viscosity at different temperatures and change in viscosity, sludge and carbon formation, and oil consumption during 50-hr. engine test.

M

MACHINE SHOPS

Modernization. Relocation, Rearrangement Re-Equipment, T. O. Ford Am. Mach., vol. 75, no. 9, Aug. 27, 1931, pp. 339–343, 9 figs. Modernization in machine division of Norton Co., Worcester, Mass. manufacturing grinding and lapping machines; diagram illustrates shop layout before and after changes.

MACHINE TOOLS

Design. Building Special Machinery on the Unit Plan. Machy. (Lond.), vol. 38, no. 984, Aug. 20, 1931, pp 661–663, 9 figs. Gradually growing practice of designing special machinery so that it can be assembled from unit mechanisms greatly reduces costs; example of Millholland Sales & Engineering Co., Indianapolis.

Les tendances actuelles en construction des machines-outils (Present Tendencies in Design of Machine Tools), E. Bodart. Revue Universelle des Mines, vol. 6, no. 4, Aug. 15, 1931, pp. 99 110. 12 figs. Factors governing design and construction of different kinds of machine tools.

Hydraulic Drive. Hydraulic Operation of Machine Tools, F. Horner. Mech. World, vol. 90, nos. 2328 and 2330, Aug. 14, 1931, pp. 145–147, and Aug. 28, pp. 202–204, 10 figs. Aug. 14: Advantages of hydraulic systems; range of pump and transmission units brought out by Greenwood and Batley Limited, of Leeds, under Hele-Shaw Beacham patents. Aug. 28: Oilgear pumps manufactured by Oilgear Co., Milwaukee, Wis.; Lauf-Thoma hydraulic gear made by Madgeburger Werkzeugmaschinenfabrik A.-G.

Manufacture—Germany. Chilling the Wearing Surfaces of Large Machine-Tools, U. Kauermann. Iron Age, vol. 128, no. 12, Sept. 17, 1931, pp. 760–764, 8 figs. Chilling of slides and slide-ways of heavy machine-tool castings as practiced by German builder of heavy tools; molding and chilling of upright for large vertical boring mill; molding of bedplate casting for heavy crankshaft lathe.

MACHINERY

Replacement—Financing. Financing Replacement Through Cost Reduction, H. B. Lewis. Iron Age vol. 128, no. 3, July 16, 1931, pp. 161–164, 3 figs. Advantages of instalment principle in replacing machinery in industrial plant.

MALLEABLE-IRON CASTINGS

Annealing. Composition, Temperature, Time and Control Govern Short Anneal, E. Bremer Foundry, vol. 59, no. 16, Aug. 15, 1931, pp. 32–34, 4 figs. Typical annealing cycle with oven and castings temperature; proper finishing temperature for white iron in relation to carbon content; time required to complete 90 per cent of carbide decomposition between 1112 and 1652 deg. fahr.; chemical and physical properties of annealed bars.

MATERIALS HANDLING

Rehandling in Process. Re-Handling of Materials in Process, R. J. Waldo. Mech. Handling, vol. 18, no. 8, 1931, pp. 256–258, 3 figs. Relation of materials rehandling and production costs; material handling equipment for special requirements; economic advantage of materials-handling equipment to small plant.

Stocking Parts. Overcoming Basic Difficulties in Stocking 60,000 Active Parts Minneapolis-Honeywell Regulator Co. Keeps Pace With Rapid Development, J. R. Freyermuth. Matls. Handling and Distribution, vol. 6, no. 5, Aug. 1931, pp. 34–39 and 41, 5 figs. Materials-handling methods employed in Minneapolis-Honeywell Regulator Co.

MATERIALS TESTING

High Temperatures. Materials at High Temperatures, R. G. Batson and H. J. Tapsell. Int. Congress for Testing Matls.—Advance Paper, 1931, 8 pp., 2 figs. Historical account of researches on behavior of materials at high temperatures carried out in England; features which are encountered in prolonged tests; very satisfactory method of test consists in estimating stresses corresponding to rate of creep of about 10–5 in. per day at end of 40 days' test; endurance limits and limiting creep stresses for variety of steels.

METAL DRAWING

Lubricants for. Lubricants for Deep Drawing, M. Reswick. Metal Progress, vol. 20, no. 3, Sept. 1931. pp. 69–73, 3 figs. Characteristics and functions of various lubricating compounds with data on composition, use, and economy; "border-line" compounds; film of lead oleate stands up under loads six times as heavy as cylinder oil can carry.

Stretcher Strain. Stretcher Strains Depend Upon Speed of Draw, J. Winlock and A. E. Lavergne. Metal Progress, vol. 20, no. 3, Sept. 1931, pp. 90–93, 5 figs. Investigation by E. G. Budd Mfg. Co.; low carbon steel best suited for deep drawing purposes when in semi-plastic condition; deformation at fast speed prevents stretcher strain.

METALS

Corrosion. Stress Corrosion of Metals, D. J. McAdam, Jr. Int. Congress for Testing Matls.—Advance Paper, 1931, 19 pp., 6 figs. Correlation and discussion of results of extensive investigation of stress corrosion, at U. S. Naval Engineering Experiment Station, presented in previous papers, with addition of some more recent data; corrosion-fatigue of carbon and ordinary steels, stainless steels, nickel and monel metal; corrosion fatigue limits; total damage and net damage; strengthening by understressing; influence of stress range and cycle frequency on corrosion; results of tension and Charpy impact tests.

Methods for Testing the Corrosion Resistance of Light Metal Alloy Sheets, M. Abraham. Metal Industry (Lond.), vol. 39, nos. 3 and 4, July 17, 1931, pp. 51–53, and July 24, pp. 77–79, 6 figs. July 17: Test specimens; apparatus; dipping method; spraying method; outdoor exposure tests. July 24: Alteration in surface; alteration in microstruction; alteration in weight; alteration in mechanical properties; alteration in number of bends; alteration in Erichsen values.

Fatigue. Ermuedung (Fatigue), P. Ludwik. Int. Congress for Testing Matls.—Advance Paper, 1931, 17 pp., 2 figs. Comparative tensile, repeated bending and repeated torsional tests on polished and notched test pieces and on test pieces with collars; repeated impact tests; corrosion tests of long duration under bending and torsion on various constructional and tool steels, cast iron, light metals and non-ferrous metals; prolonged corrosion tests in sea-water.

The Present State of Knowledge of Fatigue of Metals, H. J. Gough. Int. Congress for Testing Matls.—Advance Paper, 1931, 21 pp. Discussion regarding whether agreed conclusions are reached; suggestions for future research, particularly indicating where international co-operation is desirable; international standardization of technical terms relating to fatigue.

Ueber die Entwicklung der Dauerpruefung in Deutschland (The Development of Fatigue Testing in Germany), E. H. Schulz and H. Buchholtz. Int. Congress for Testing Matls.—Advance Paper, 1931, 25 pp., 36 figs. Critical survey; development of testing apparatus; effect of chemical composition, structure, and treatment of material; sensitivity to notches or cracks under simple alternating stress and under compound dynamic and static stress; effect of skin on fatigue strength of tempered flat springs; vibration tests under corrosive conditions.

Magnetic Hardening. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. Metallurgia, vol. 4, no. 20, June 1931, pp. 47–50, 10 figs. Precession theory of hardening; graphs illustrating results of experimental work, leading to new conception of philosphy of hardening, including quench-hardening, work-hardening, age-hardening, and hardening of work-hardened metals by low-temperature annealing. Bibliography.

MOLDING

Piece Rates. Point System for Determining Molding Rate and Costs. Iron Age, vol. 128, no. 10, Sept. 3, 1931, pp. 614–615. Reliable method of establishing equitable molding piece rates; can be used by sales department for estimating costs and quoting on job; experience of Federal Malleable Co., Milwaukee, using system since 1922.

MOTOR TRUCKS

Diesel. Fahreigenschaften von Dieselmotoren und Vergasermotoren in Nutzkraftwagen (Operating Characteristics of Diesel Engines and Carburetor Engines for Motor Trucks), P. Langer. V.D.I. Zeit., vol. 75, no. 30, July 25, 1931, pp. 949–953, 14 figs. Comparative road tests with various types of Diesel engines and carburetor engines illustrate superiority of Diesel engines, particularly at low speed and with regard to fuel economy; graphs illustrate pressure rise, fuel consumption, acceleration, etc.

N

NICKEL STEEL

X-Ray Analysis. X-Ray Investigation of Certain Nickel Steels of Low-Thermal Expansion, G. Phragmen. Iron and Coal Trades Rev., vol. 123, no. 3306, July 10, 1931, pp. 40–41, 7 figs. Experiments show that low-thermal dilatation is property of face-centered cubic phase when containing about 36 per cent of nickel; low dilatation coefficient is not due to two-phase reaction which compensates normal dilation of two phases; thus there is scarcely any reason to assume presence of body-centered cubic phase in low-expansion alloys; occurrence of maximum in specific volume, taken as function of composition, has been verified.

NITRIDATION

Crystal Structure and Hardness. Correlation of the Crystal Structures and Hardnesses of Nitrided Cases, O. E. Harder and G. B. Todd. Am. Soc. Steel Treating—Preprint, no. 6, for mtg. Sept. 21–25, 1931, 22 pp., 14 figs. Samples of open-hearth ingot iron, S.A.E. 1025 steel, chromium-aluminum nitriding steel, and two chromium-aluminum-molybdenum nitriding steels have been nitrided 72 hr. at 975 deg. fahr.; specimens have been subjected to X-ray examination, hardness tests, and microscopic examination in original surface and at various depths below surface.

Short-Time Nitriding. Short-Time Nitriding, J. J. Egan. Am. Soc. Steel Treating—Preprint, no. 19, for mtg. Sept. 21–25, 1931, 16 pp., 17 figs. Improved methods of nitriding, namely, duplex cyanide treatment, use of ammonia and nitric oxide, ammonia with nitrogen-containing compounds, and activated sand as packing material; use of electric spark in nitriding chamber, ultraviolet irradiation of specimen during treatment, and high frequency heating; methods all result in appreciable cases in much shorter period of time than is possible by present methods.

Temperature of. Nitriding in Industry, J. Muller. Soc. Automotive Engrs.—Jl., vol. 29, no. 3, Sept. 1931, pp. 236–240 and (discussion) 240, 8 figs. Temperature of nitriding affects both surface hardness and hardness gradient within case, maximum hardness being in inverse ratio to temperature of reaction; furnace designed to give reversing circulation is described and illustrated; new duplex method of treatment, in which work is done at two different temperatures.

NOISE

Measurement. The Measurement of Noise, a New Service of Electrical Research Products, Inc., S. K. Wolf. Bell Telephone Quarterly, vol. 10, no. 3, July 1931, pp. 189–192, 6 figs. on supp. plates. Widespread use of machinery and growth of congested municipalities have created noise problems which have become acute; since Bell Telephone Laboratories had already developed instruments and techniques capable of solving problems such as these, their aid was naturally enlisted; equipment used is illustrated and described

NOZZLES

Discharge Through. Die Stroemung durch Duesen und Blenden (Flow Through Nozzles and Diaphragms), R. Witte. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, nos. 3 and 4, July 1931, pp. 245–251 and Aug. 1931, pp. 291–302. Results of investigations; pressure and flow equations: expansion in flow through different types of nozzles and diaphragms; law of similitude applied to expansions; interruptions in flow with small Reynolds coefficients and during discharge.

O

OIL FUEL

Combustion. The Combustion Characteristics of Fuel Oil, B. J. Cross. Combustion, vol. 3, no. 1, July 1931, pp. 52–53, 2 figs. Analyses of fuel oils as obtained from California, Texas, and Mexico; chart showing combustion characteristics of three representative fuel oils.

OPEN-HEARTH FURNACES

Regenerators. Ueber Abmessungen und Leistungen der Waermespeicher oberschlesischer Siemens-Martin-Oefen (Dimensions and Efficiency of Regenerators of Upper Silesian Open-Hearth Furnaces), F. Wesemann. Stahl und Eisen, vol. 51, nos. 28 and 29, July 9, 1931, pp. 873–883, and July 16, pp. 908–911, 9 figs. Operating data; effect of flow velocities in duct system, especially in burner, on furnace performance and its relation to size of stack; dimensions of regenerator; influence of heating surface; calculation of temperature conditions in chambers and ducts; efficiency and specific output of heating surfaces; prospects for introduction of mixed-gas system.

P

PIPE, CAST IRON

Centrifugal Casting. The Manufacture of Sand-Spun Pipes. Engineering, vol. 132, no.

3419, July 24, 1931, pp. 93–96, 21 figs. partly on p. 108 and supp. plate. Layout, methods, and equipment of plant erected by Staveley Coal and Iron Co., near Chesterfield, for manufacture of pipes in sand molds by centrifugal casting process, under license from Sand Spun Corp. of New York and R. D. Wood and Co., of Philadelphia.

PRESSES

Hydraulic. Presswerk zur Herstellung von nahtlos gezogenen Hohlkoerpern (Presses for Manufacture of Seamless Drawn Hollow Bodies), S. Weil. Stahl und Eisen, vol. 51, no. 36, Sept. 3, 1931, pp. 1119–1121, 2 figs. Installation for manufacture of hollow cylinders up to 1450 mm. diam and 8500 mm. length, consists of hydraulic, high-speed punch press with 2500 tons pressure force, and hydraulic high-speed drawing press with 1500 ton pressure force.

PRESSURE VESSELS

Alignment Charts. Pressure Tank Design for Atmospheric and High Temperatures. West. City, vol. 7 no. 8, Aug. 1931, pp. 38–39, 1 fig. Chart designed to indicate wall thickness required for pressure tanks; elements considered are: ultimate strength of metal, factor of safety to be allowed, type and efficiency of joints of longitudinal seams, diameter of tank, and internal pressure to which it is to be subjected.

PULVERIZED COAL

Plant Experiences With. Pulverized Fuel. Nat. Elec Light Assn.—Pub., no. 148, Aug. 1931, 34 pp., 4 figs. Statements for 1930 from 24 operating companies covering: direct fired vs. bin system; new developments and operating costs on mills and exhausters; tests on various types of mills for coal fineness; experience with mill drying; vent and washing methods; boiler operation, etc.

PUMPS

Centrifugal. Versuche an einer Schaukreiselpumpe (Tests of a Transparent Centrifugal Pump), A. Closterhalfen. Dorschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 7, July 1931, pp 252–260, 14 figs. Investigations of flow; photographs and diagrams of stream flow; stray air in rotor; evaluation of test results; calculation of specific work of wheel; characteristic curves.

Vacuum. Ueber die Abhaengigkeit der von einer Hochvakuumpumpe angesaugten Luftmenge vom Vorvakuum (Dependence on Prevacuum of Air Quantity Pumped by High Vacuum Pumps), H. Ebert. Zeit. fuer Instrumentenkunde, vol. 51, no. 7, July 1931, pp. 337–341, 5 figs. Two single-stage diffusion vacuum pumps one made of steel, other of glass, have been studied in order to determine influence of pressure in pre-vacuum vessel on pumped air quantity; results are given in curves.

R

RAIL MOTOR CARS

Steam-Driven. A New Steam Rail Car for South America. Ry. Engr., vol. 52, no. 619, Aug. 1931, pp. 308–309, 2 figs. Oil-fired design built for service on mountain section of Gran Ferrocarril de Venezuela by Maschinenfabrik Esslingen; steam pressure 235 lb. per sq. in.; cylinders, 9.45 by 12.99 in.; driving wheels 33.46 in.; maximum tractive effort 5954 lb.; weight of car, empty, 27.6 tons; interior arrangements; operating conditions.

REFRIGERATING MACHINES

Absorption-Type. Die thermischen Eigenschaften von Ammomiakaten und aehlichen Verbindungen ind ihre Verwendung in Absorptions-Kaeltemaschinen (Heat Properties of Ammonium Salts and Similar Compounds and Their Use in Absorption Refrigerating Machines), R. Plank and L. Vahl. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 1, Jan. 1931, pp. 11–18. 5 figs. So-called dry absorption machines; vapor-pressure curves; heat of formation; methyl amine and methyl aminates; comparison of different systems.

S

SAND BLASTING

Nozzle Dimensions and Pressure. Duesenabmessungen und guenstigster Arbeitdruck von Sandstrahlgeblaesen (Nozzle Dimensions and Best Working Pressure of Sand Blasts), W. Kaempfer. Giesserei, vol. 18, no. 33, Aug. 14, 1931, pp. 653–656, 7 figs. Review of literature; nozzle dimensions, efficiency and performance of sand blasts; use of steel pyrites and quartz in sand blasts.

SHAFTS AND SHAFTING

Vibrations. The Vibrations of Revolving Shafts, R. C. J. Howland. Lond., Edinburgh and Dublin Philosophical Mag and Jl. Science, vol. 12, no. 76, Aug. 1931, pp. 297-311, 2 figs. Number of observations of sudden instability of shafts at high speeds were made by Newkirk and Kimball, and theory was put forward; this appears to present writer to be intrinsically unlikely, but some experimental evidence in support of suggestion was produced; effects of internal friction considered on basis of certain not improbable assumptions; results do not give support to Kimball's theory, and alternative explanations are suggested.

SHEET STEEL

Manufacture. Comparison of Sheet and Strip Steels for Difficult Stampings, E. S. Lawrence. Am. Soc. Steel Treating—Preprint, no. 11, for mtg., Sept. 21–25, 1931, 21 pp. General differences in manufacture of sheet and strip steels of low carbon variety as utilized primarily for deep and extra deep drawing automobile stampings; some of most common defects and limitations encountered in manufacture of strip steel for this particular and ultimate use are contrasted with some of more common defects attributed to manufacture of sheet steel.

Plastic Drawing. Plastic Drawing of Sheet Steel Into Shapes, E. V. Crane. Am. Soc. for Steel Treating—Preprint, no. 18, for mtg. Sept. 21-25, 1931, 21 pp., 12 figs. Extreme plastic movement of rearrangement of metal (cold) is illustrated in drawing round shells; principles developed there may be applied also to rectangular and irregular shapes; primary stress is tensile stress in shell wall which is rarely in necking range and often below yield point; resultant compressive stress in flange area during drawing must always exceed annealed yield point and often rises to necking range stresses well above nominal ultimate tensile strength.

SPRINGS

Phosphor-Bronze. On the Properties of Phosphor-Bronze for Springs, M. Tanaka and T. Ogawa. Electrotech. Laboratory Japan—Researches, no. 301, Jan. 1931, 85 pp., numerous figs. Results of test with metal containing less than 10 per cent of tin and 0.5 per cent of phosphor; test specimen of different compositions were annealed at various temperatures; melting point, density, coefficient of linear expansion, ultimate tensile strength, Young's modulus, elastic limit, specific resistance, and temperature coefficient of resistance were determined. (In Japanese with English abstract.)

STEAM

High-Pressure. Steam Pressures and Temperatures Trend Higher, D. S. Jacobus. Elec. World, vol. 98, no. 10, Sept. 5, 1931, pp. 410–414, 9 figs. Article is intended for electrical man to learn about modern trends in high-pressure steam practice; notes on new kind of superheater; slag-tap furnace: lower grade fuels, stock ash; development of boiler welding; pressure of range of 1400 lb. Before Am. Inst. Elec. Engrs. and West. Soc. Engrs.

Research. Steam Research in Europe and in America—I, M. Jakob. Engineering, vol. 132, no. 3420, July 31, 1931, pp. 143–146, 5 figs. Review of research work in different countries; fundamental thermodynamical properties of water and steam; saturation line of steam; specific volume of water; superheated steam; Callendar and saturated steam; measurements of Thomson-Joule effect. Before Univ. Lond.

Superheated. See SUPERHEATED STEAM.

STEAM CONDENSERS

Operation. Betriebserfahrungen mit grossen Kondensationsanlagen (Operating Experience With Large Condensers), K. Dolzmann. Elektrizitaetswirtschaft, vol. 30, no. 14, July 1931, pp. 402–407, 8 figs. Operating data from condenser equipment of 182 steam turbines of at least 10,000 kw. nominal output; important problems of condenser design compared; reports on treatment of condensers listed; kinds and frequency of troubles experienced in 1930.

Tube Corrosion. Seasonal Variation in Rate of Impingement Corrosion, A. Morris. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 431, 1931, 9 pp., 4 figs. Tests conducted at Bridgeport, Conn., within two miles of mouth of Pequonnock River; apparatus and procedure of instrument test; analyses of alloys tested; experience during three years shows that increased corrosion was coincident with period when water gave off unpleasant odor characteristic of such waters in warm weather; increased rate of attack during summer months is clearly indicated; seasonal variation shown is greater than difference between any pair of metals tested.

STEAM-ELECTRIC POWER PLANTS

London. Scientific Coordination of Fuel Utilization, D. Brownlie. Combustion, vol 3, no. 1, July 1931, pp. 47–49 and 51, 3 figs. Various developments such as recovery of by-products from coal before its use as fuel, recovery of sensible heat from hot coke, and use of steam at high pressure for power generation and its subsequent use at lower pressure for other purposes, are being coordinated in connection with large industrial and power projects wherever practicable; preliminary description of new Ford plant, now being constructed near London, as outstanding example of this modern trend.

Milwaukee. Lakeside—A Decade of Progress. Power Plant Eng., vol. 35, no 15, Aug. 15, 1931, pp. 830–837, 13 figs. Now up to ultimate capacity; Lakeside station, built at cost of $80 per kw. of capacity, has played dominant part in power plant industry since 1920; reduction in heat rate from 21,000 B.t.u. per kw-hr. in 1921 to about 13,500 in 1931 evidence of successful fight against obsolescence; pulverized coal firing; radiant superheaters and reheaters; high pressures; reheat cycle; flue gas mill drying; smoke washers; and exhausters on inlet side of pulverizing mill were pioneering developments; trend of design as shown by data covering period of 10 yr.

Stand-By. Die Verbund-Spitzenkrafterzeugung durch Pump- und Ruths-Speicherwerke (Combined Peak Load Supply Through Pumped Storage and Ruths Accumulators), H. Schulze. Elektrotechnische Zeit., vol. 52, no. 31, July 30, 1931, pp 992–994, 4 figs. On basis of cost study, it is suggested to operate pumped storage plants in regions supplied by steam plants in combination with Ruths accumulators; principal directions for such combined peak-load generation are given and savings over peak-load generation by pumped storage only are calculated in simple example.

STEAM ENGINES

Lubrication. Die Schmierung der Dampfmaschinenzylinder (Lubrication of Steam-Engine Cylinders), Hilliger. Waerme, vol. 54, no. 34, Aug. 22, 1931, pp. 625–630, 8 figs. Investigation of problems involved; wear of gliding surfaces; lubricating equipment; oil lines and distribution.

STEAM PIPE LINES

Pressure Losses. Druckverlust in Dampfleitungen (Pressure Loss in Steam Pipe Lines), E. Kaschny. Waerme, vol. 54, no. 34, Aug. 22, 1931, pp. 635–636, 2 figs. Formulas employed for calculation of pressure losses and coefficients of flow resistance; practical examples.

STEAM POWER PLANTS

Ash Handling. Steam Jet Vs. Vacuum Ash Conveyors, E. Hahn. Combustion, vol 3, no. 1, July 1931, pp. 50–51, 2 figs. Operation of both types of conveyors analyzed and conclusion is reached that steam-jet conveyor in which steam jet is admitted at some intermediate point in line thus combining suction and pressure in process of ash removal, is better type.

Coal Handling. Handling Coal and Ashes at Longworth Steam Station, H. V. Schiefer. Combustion, vol. 3, no. 2, Aug. 1931, pp. 35–38 and 61, 5 figs. Design and operating characteristics of coal and ash-handling installation in Longworth Steam Station; plan, elevation and cross-section of Longworth Station.

Design. Balancing Supply and Consumption of Energy, C. H. S. Tupholme. Combustion, vol. 3, no. 1, July 1931, pp. 41–44 and 54, 3 figs. Review of power-plant practice and trends in Great Britain and Europe; plant load chart showing effect of daily energy storage; heat-flow diagram of paper-mill power plant; heat-balance diagram for combined heating and power plant.

Fuel Economy. Einfluss von Anzapfvorwaermung, Druckerhoehung, und Lastschwankungen auf die Energiekosten (Influence of Bleeder Preheating, Pressure Increase, and Load Fluctuations on Cost of Power), F. Huettner. Waerme, vol. 54, nos. 33 and 34, Aug. 15, 1931, pp. 609–614, and Aug. 22, pp 631–634, 10 figs. Method of calculating power costs; influence of fuel-economy measures on power costs is determined, as well as influence of fluctuating load.

High-Pressure. Erfahrungen mit Hoechstdruckanlagen (Experiences With Super-Pressure Plants), Marguerre. Zeit. des Bayerischen Revisions-Vereins, vol. 35, no. 9, 10, 11, 12, 13, and 14, May 15, 1931, pp. 97–99, May 31, pp. 107–111, June 15, pp. 124–130, June 30, pp. 133–135, July 15, pp. 158–163, and July 31, pp. 168–173, 29 figs. Based on experiences with high-pressure